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Pennisi

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(54) **SELF POWERED OPTICAL SYSTEM**

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(51) **Int. Cl.**

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H04B 1/04	(2006.01)
H02J 5/00	(2016.01)

(52) **U.S. Cl.**

CPC ***H02N 11/002*** (2013.01); ***H02J 5/005*** (2013.01); ***H02J 50/10*** (2016.02); ***H04B 1/04*** (2013.01); ***H04B 10/58*** (2013.01)

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CPC H02N 11/002; H02J 50/10; H02J 5/005; H04B 10/58; H04B 1/04

See application file for complete search history.

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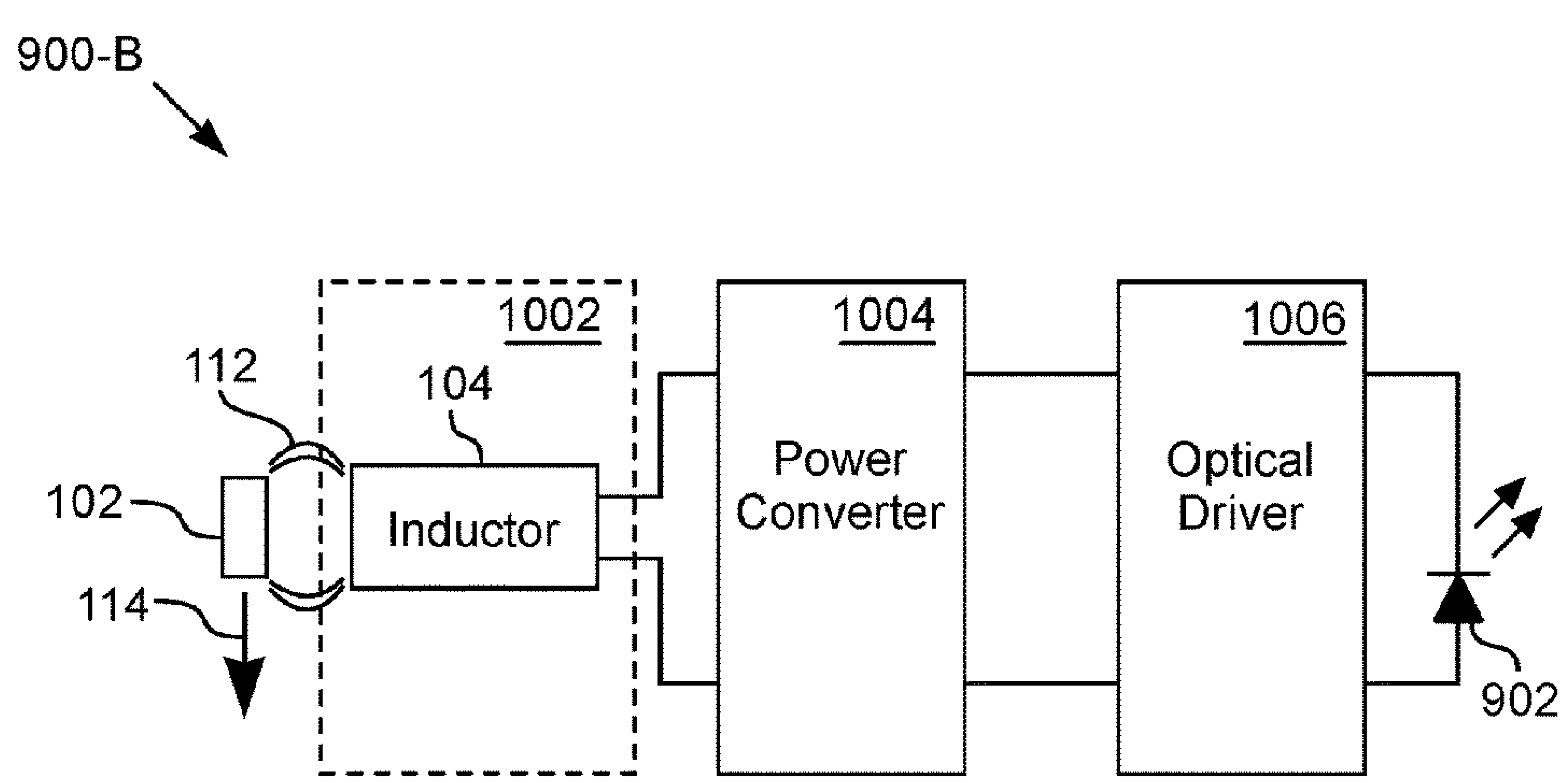
(57) **ABSTRACT**

Apparatus for a self-powered optical transmitter system. One such system includes an inductor, a power converter, an optical driver, and an optical transducer. A magnet interacting with the inductor generates and EMF that is applied to the power converter, which provides power for the optical transducer. In various embodiments, the power converter includes a voltage multiplier, such as a semiconductor circuit or a transformer, and/or a Zener diode to limit the voltage applied to the optical transducer. The optical driver is either inherent in the power converter or a separate circuit such as one including a processor. The processor has at least one input and produces an output that modulates the optical transducer.

20 Claims, 7 Drawing Sheets



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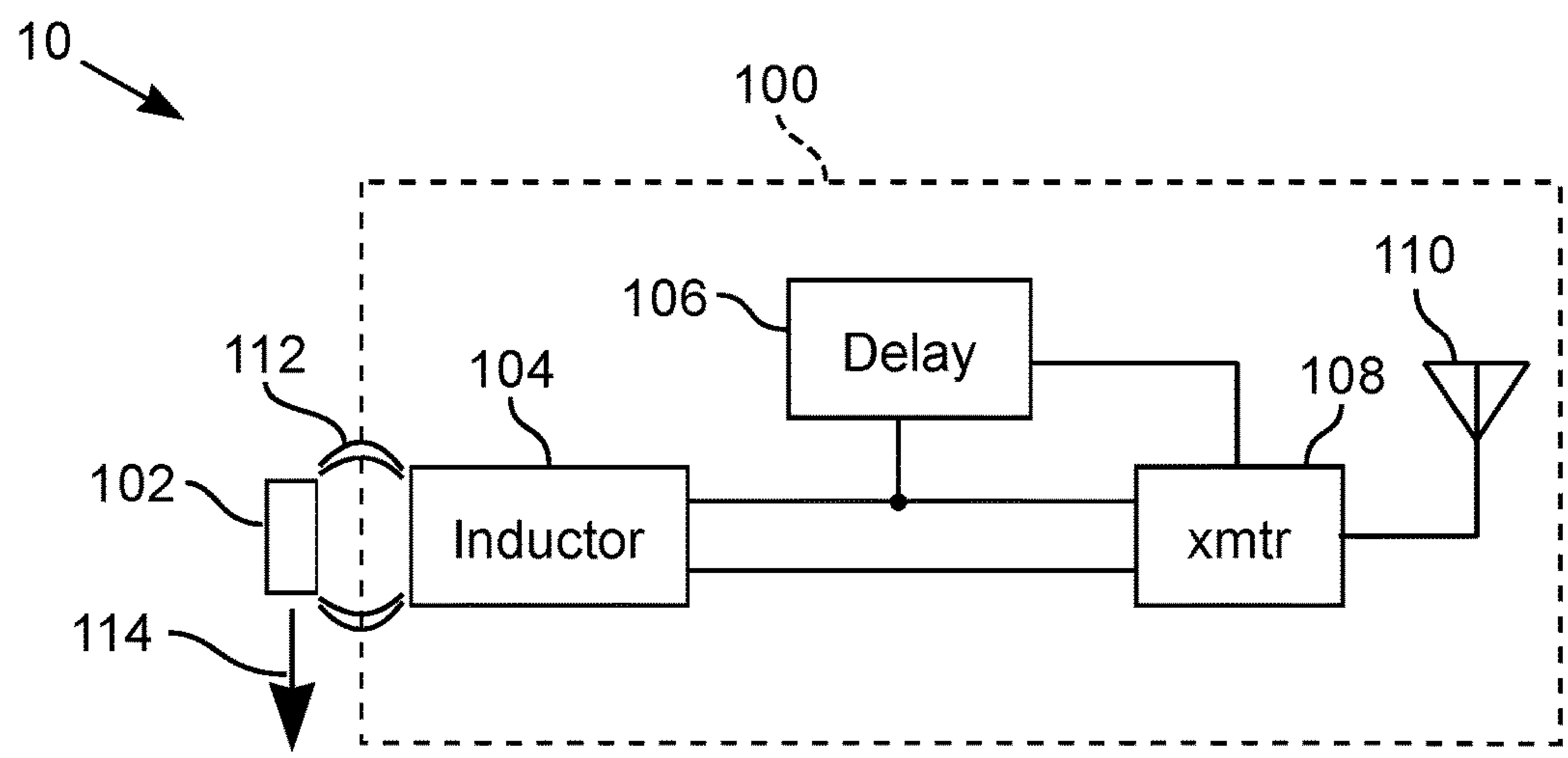
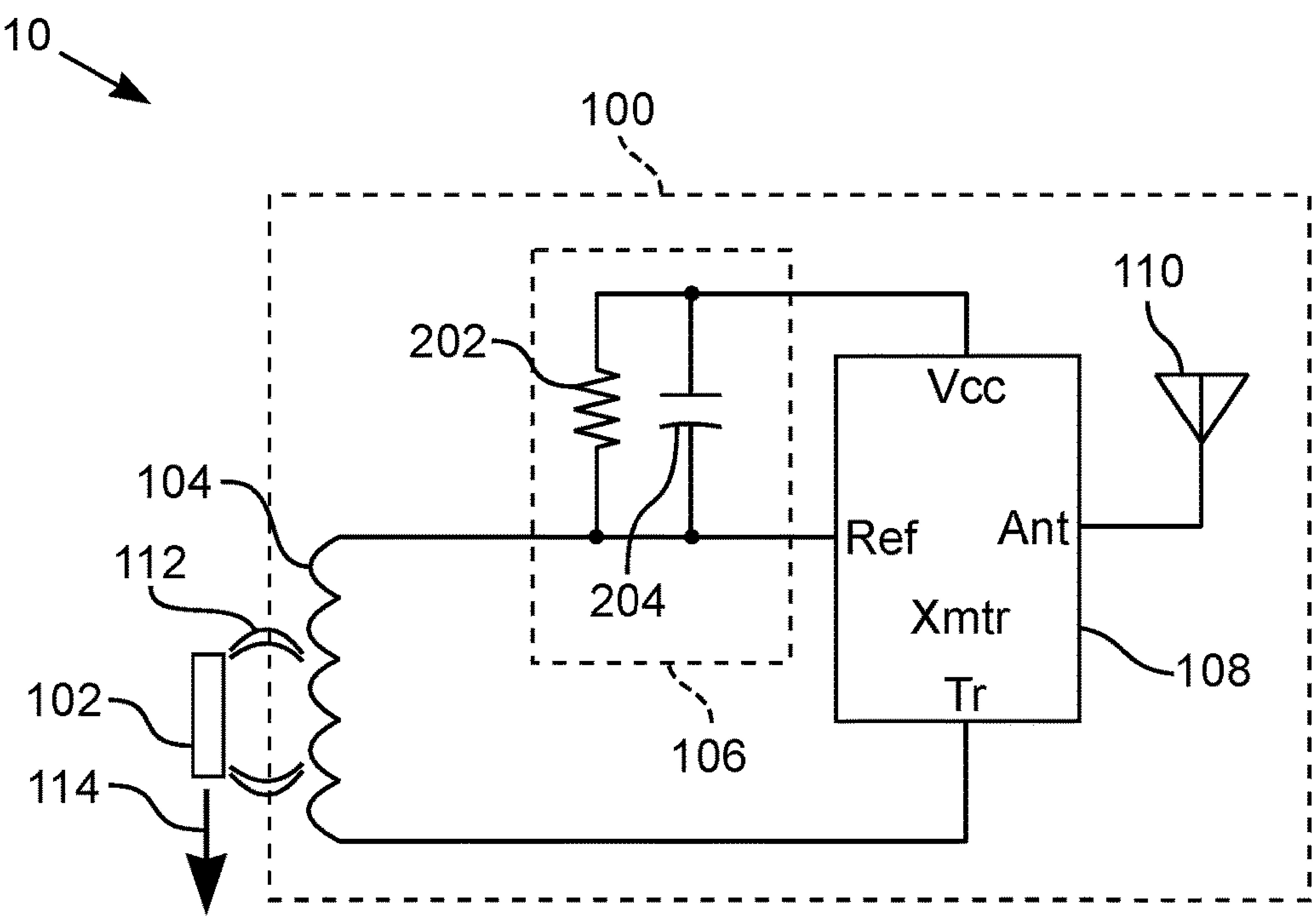

10
100
106
Delay
110
112
104
108
102
Inductor
xmtr
114

Fig. 1


10
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202
Vcc
104
Ref
Ant
112
204
Xmtr
102
108
Tr
114
106

Fig. 2

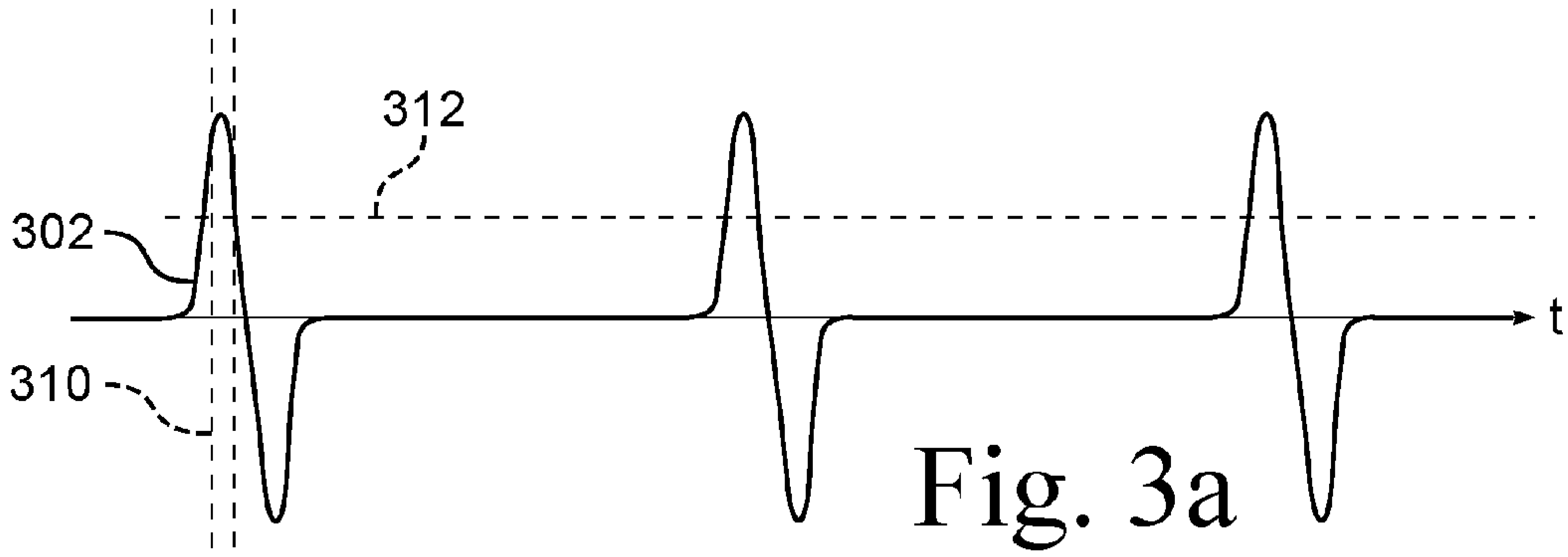


Fig. 3a

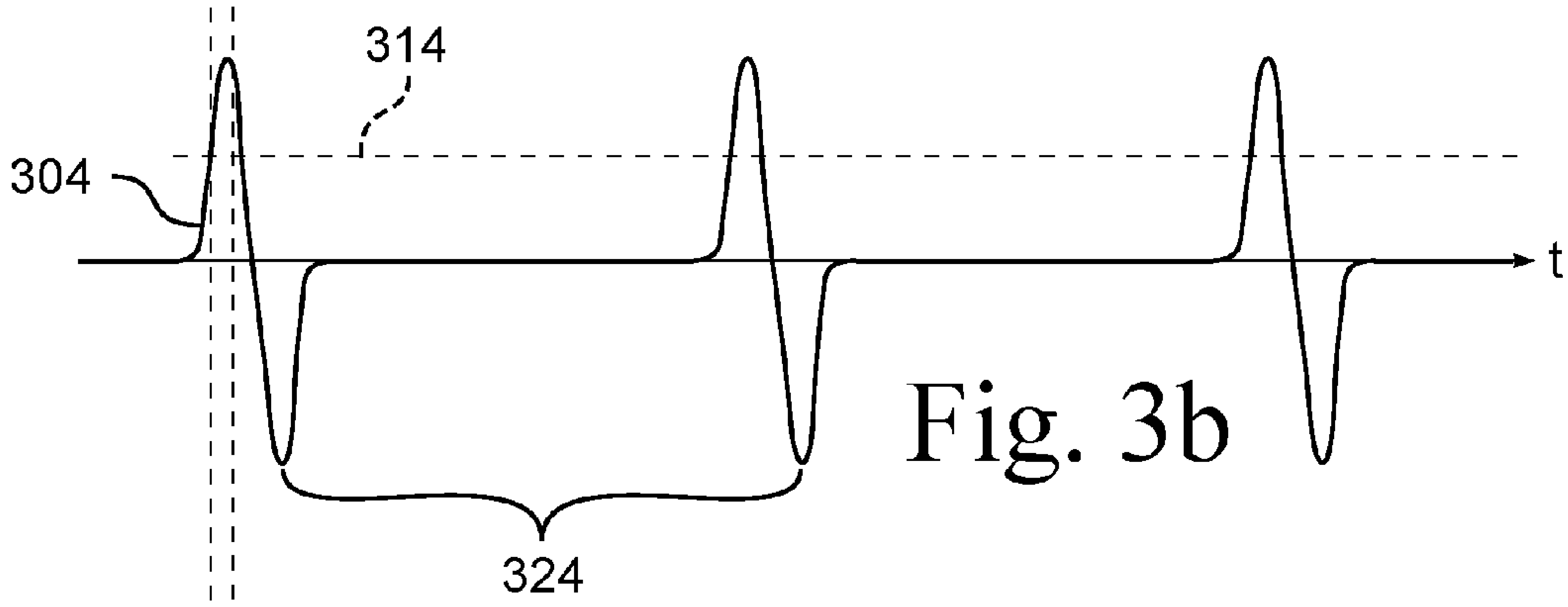


Fig. 3b

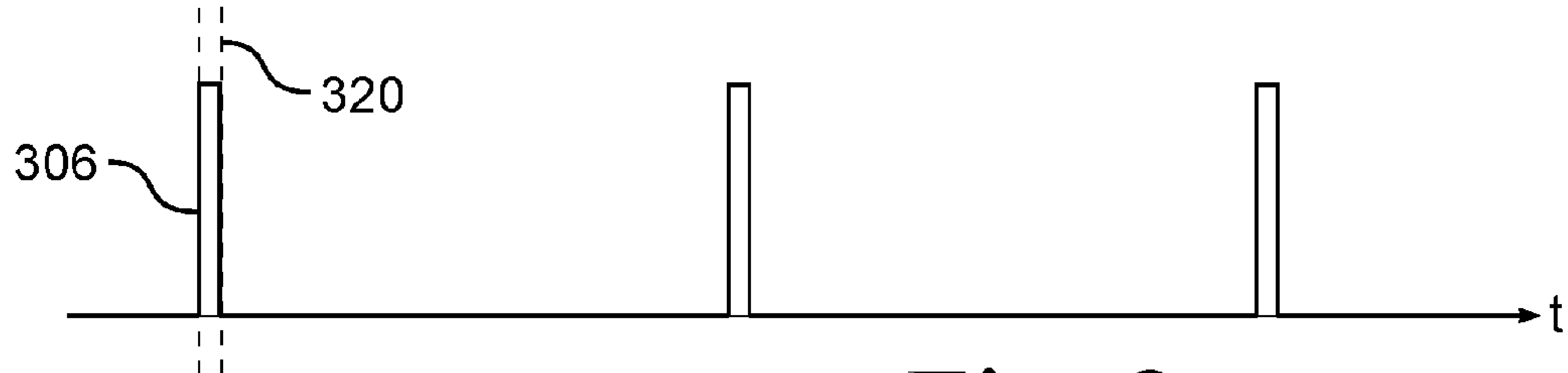


Fig. 3c

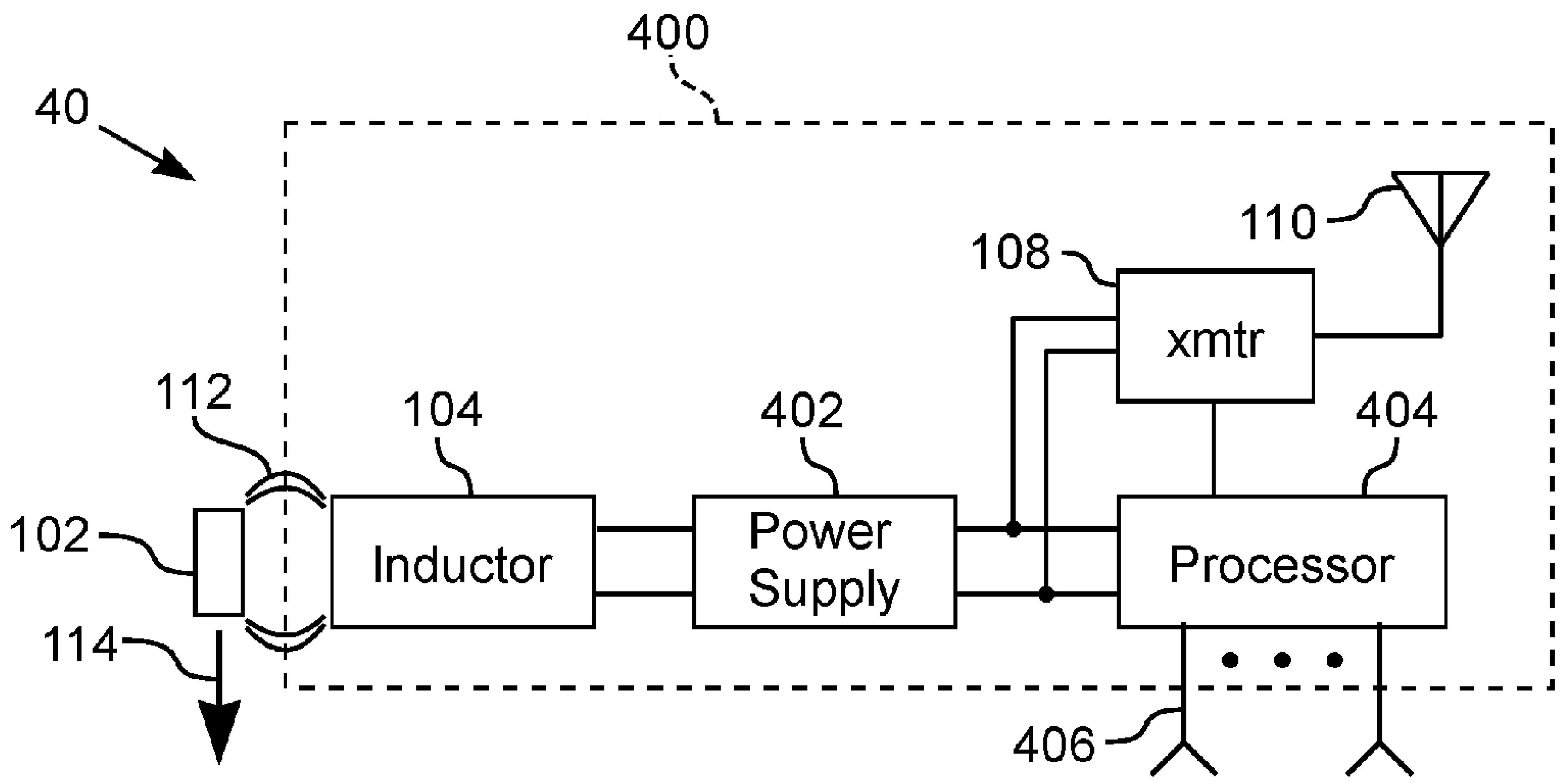

400
40
110
108
xmtr
112
104
402
404
102
Inductor
Power Supply
Processor
114
406

Fig. 4

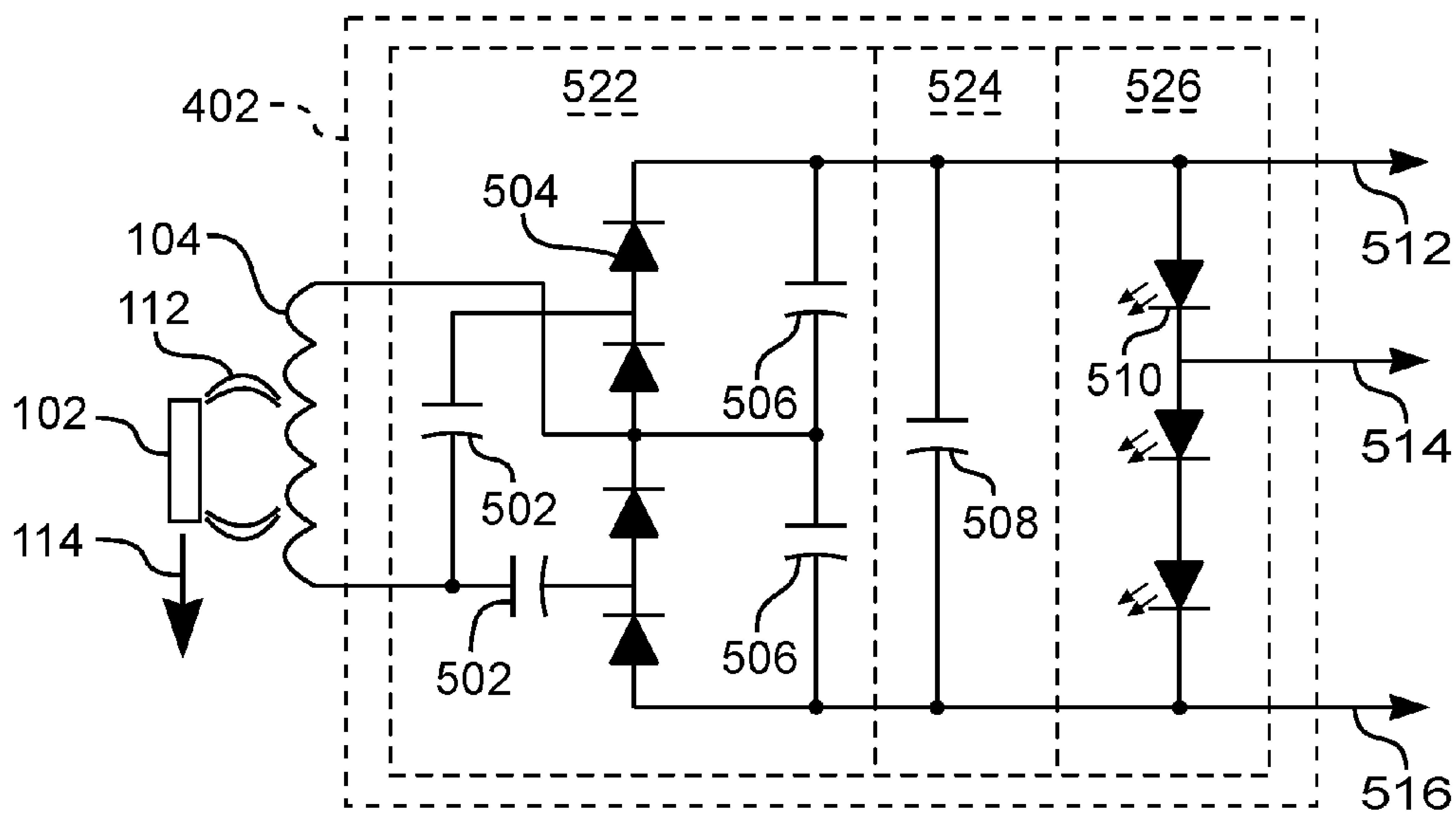

522
524
526
402
504
104
112
506
510
102
502
508
114
502
506
512
514
516

Fig. 5

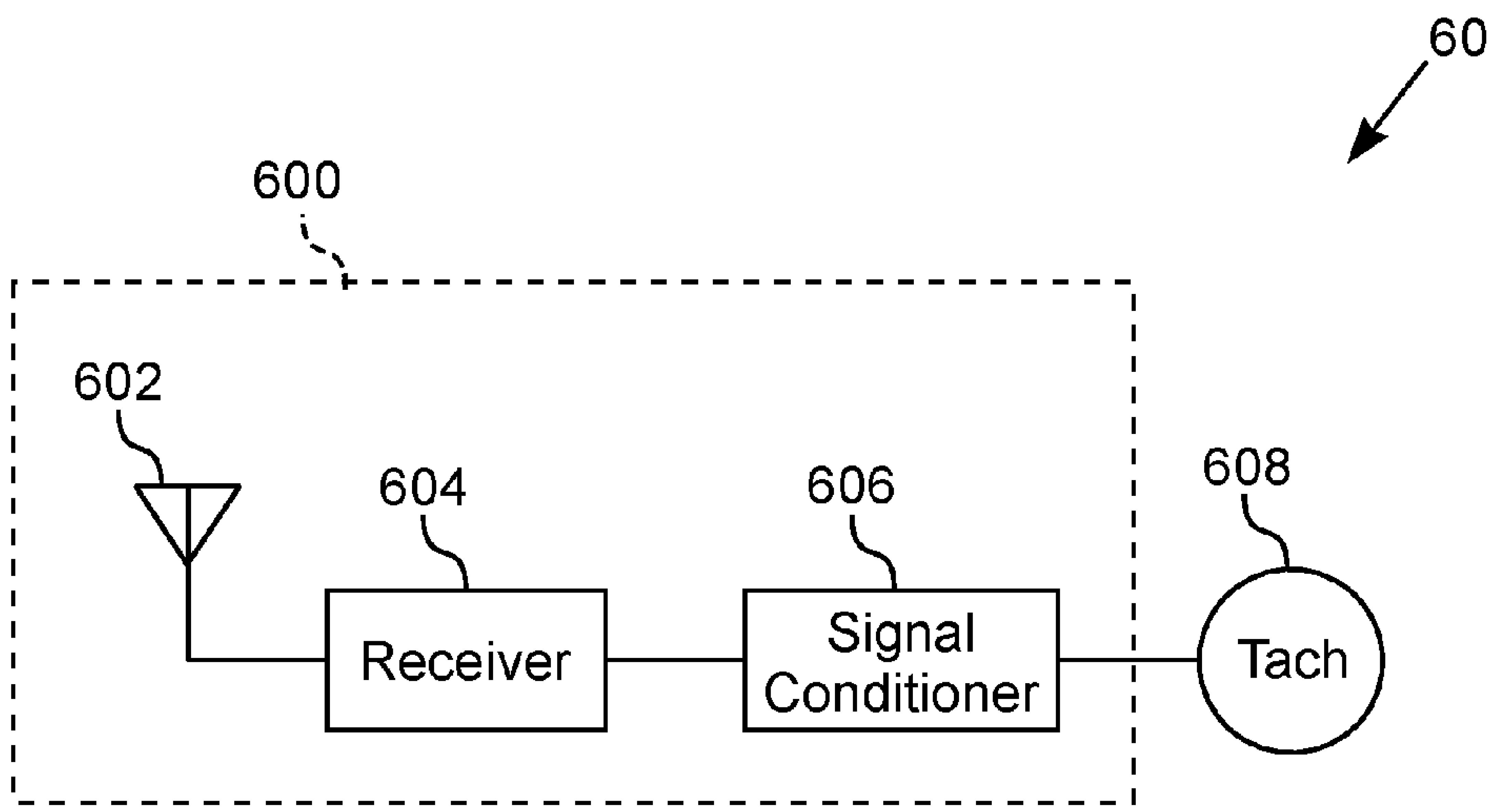


Fig. 6

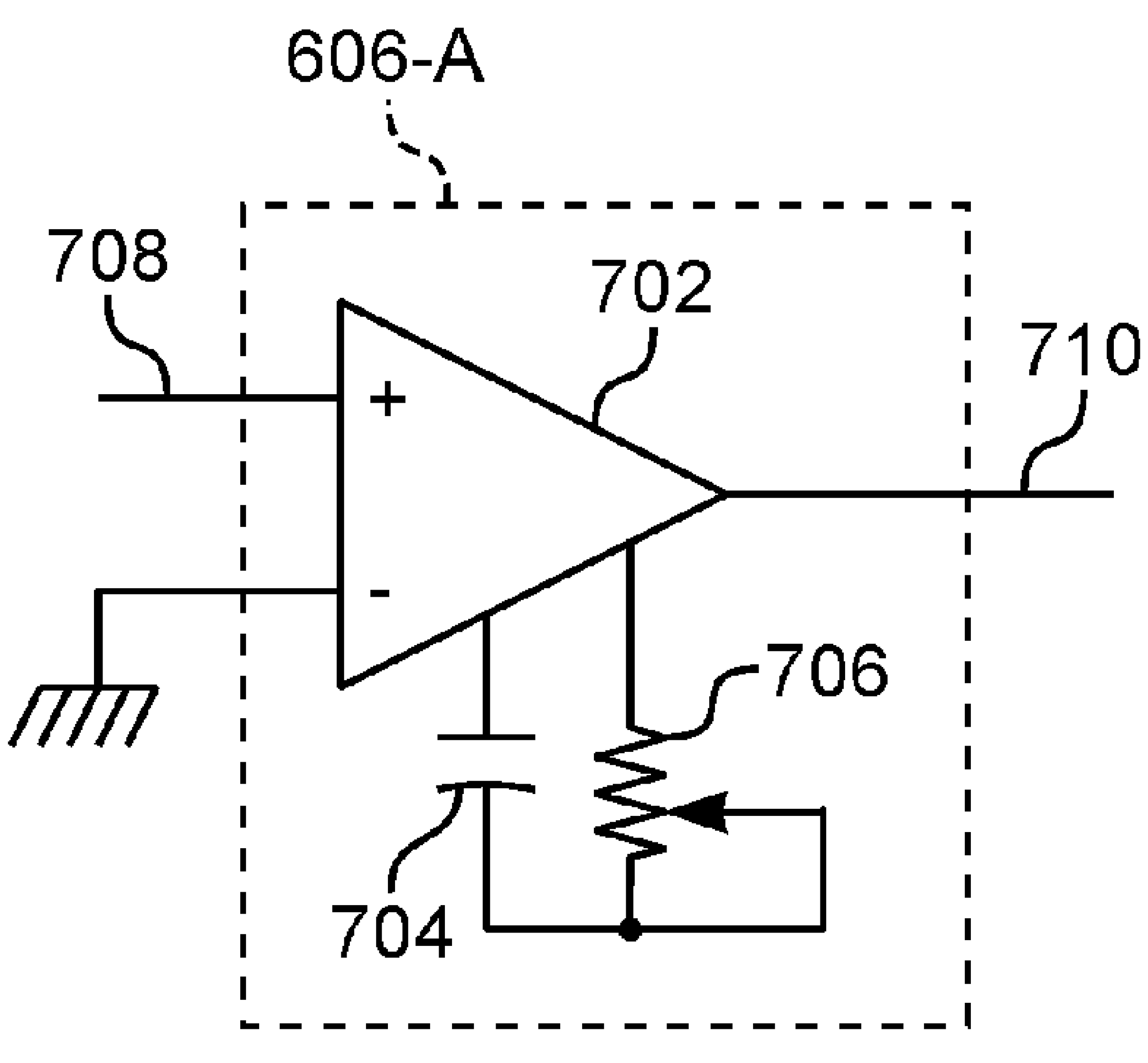


Fig. 7

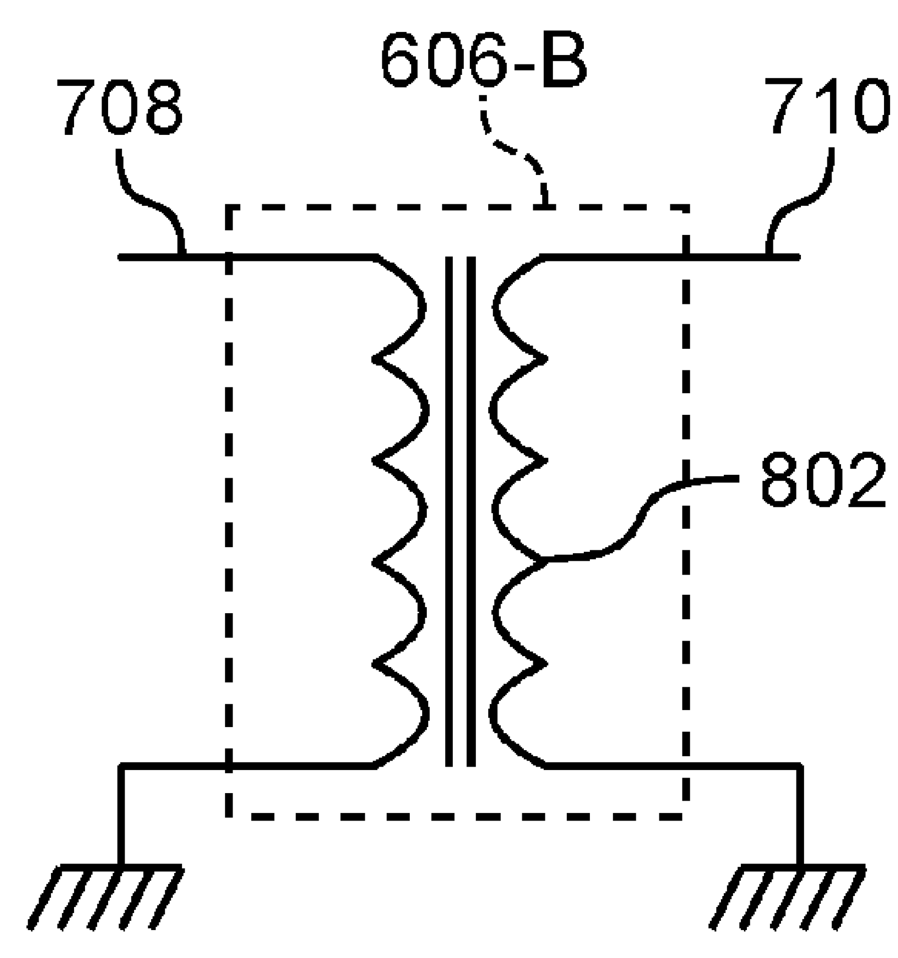
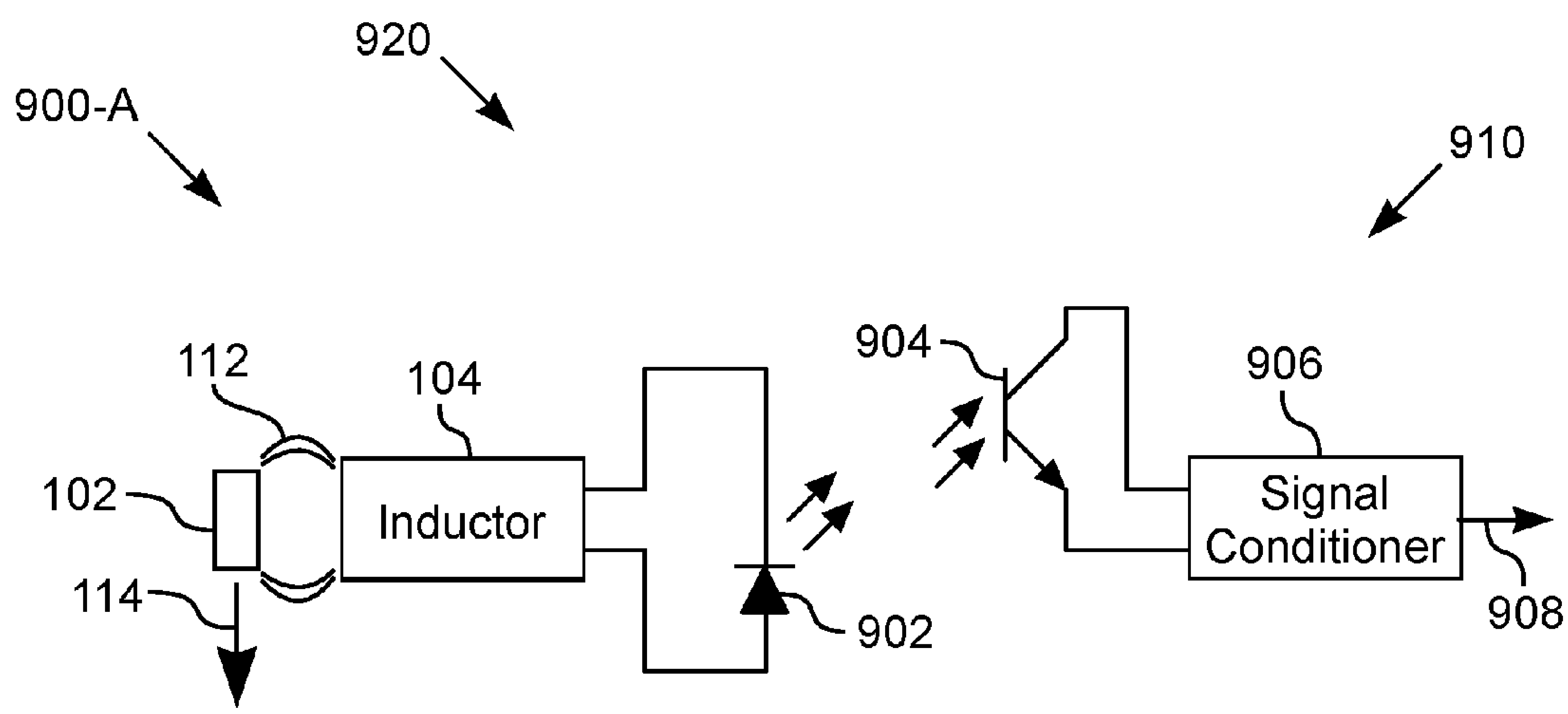
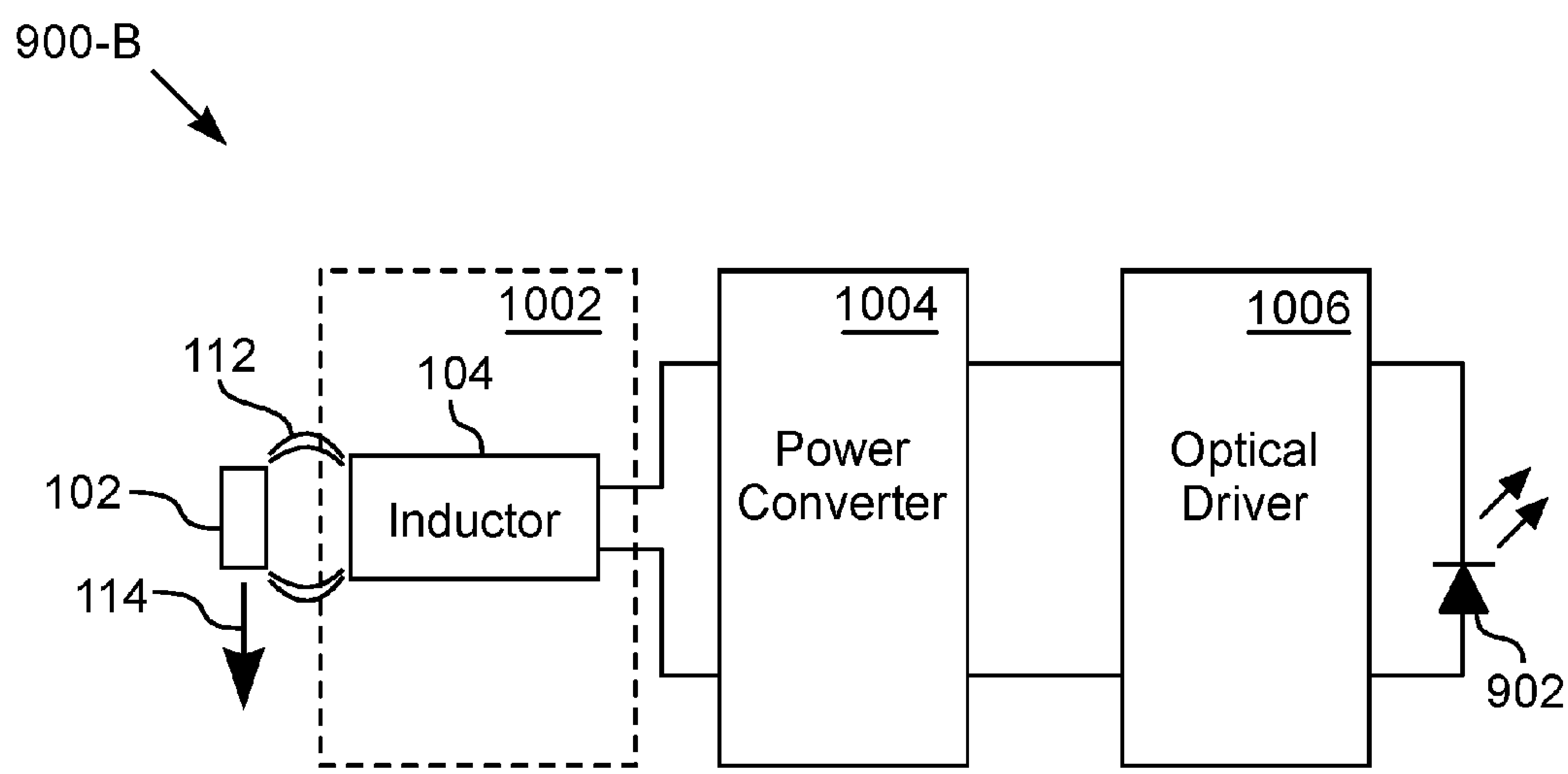


Fig. 8



900-A
920
910
112
104
904
906
102
Inductor
Signal Conditioner
114
902
908

Fig. 9



900-B
1002
1004
1006
112
104
102
Inductor
Power Converter
Optical Driver
114
902

Fig. 10

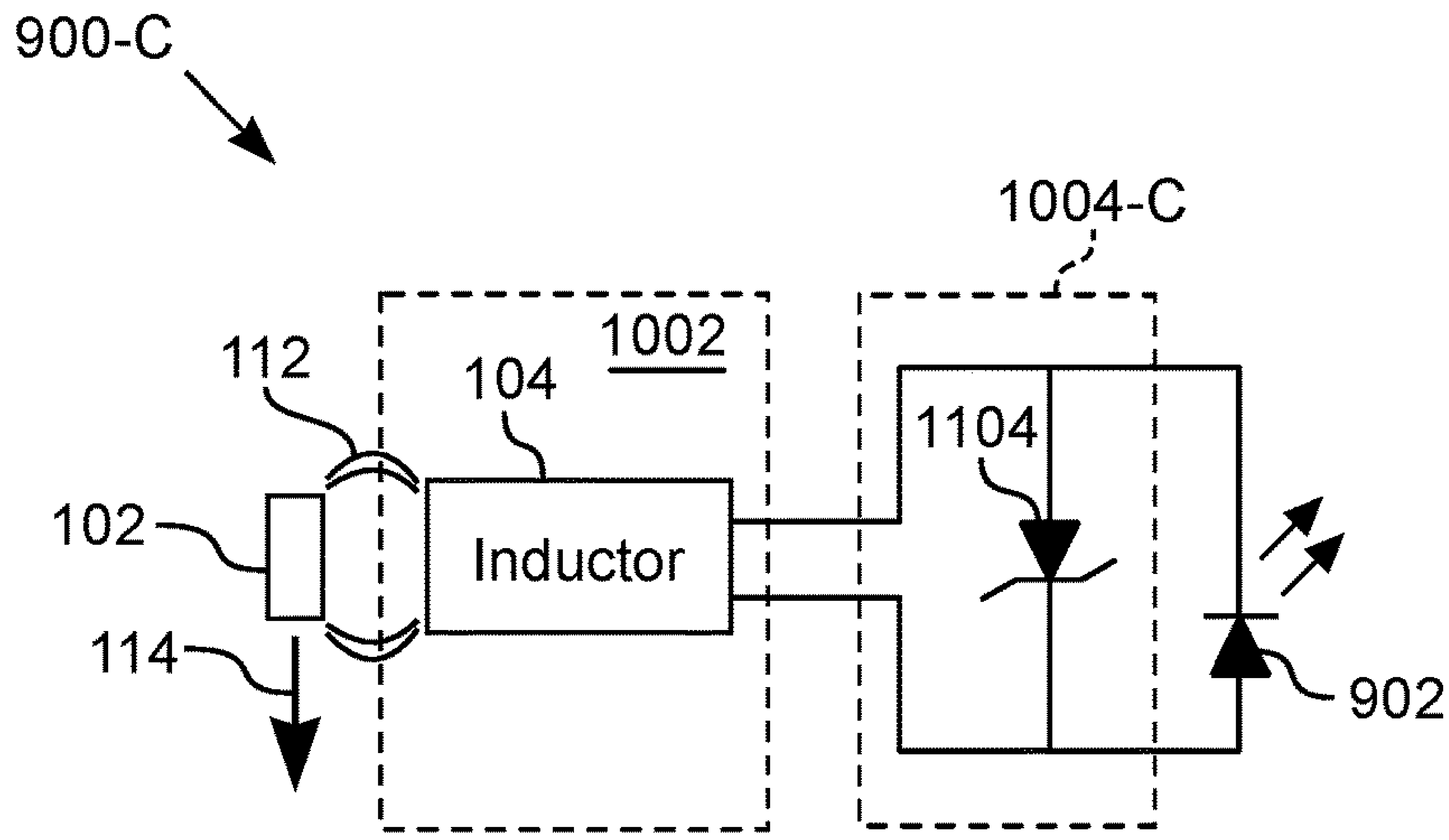

900-C
1004-C
1002
112
104
1104
102
Inductor
114
902

Fig. 11

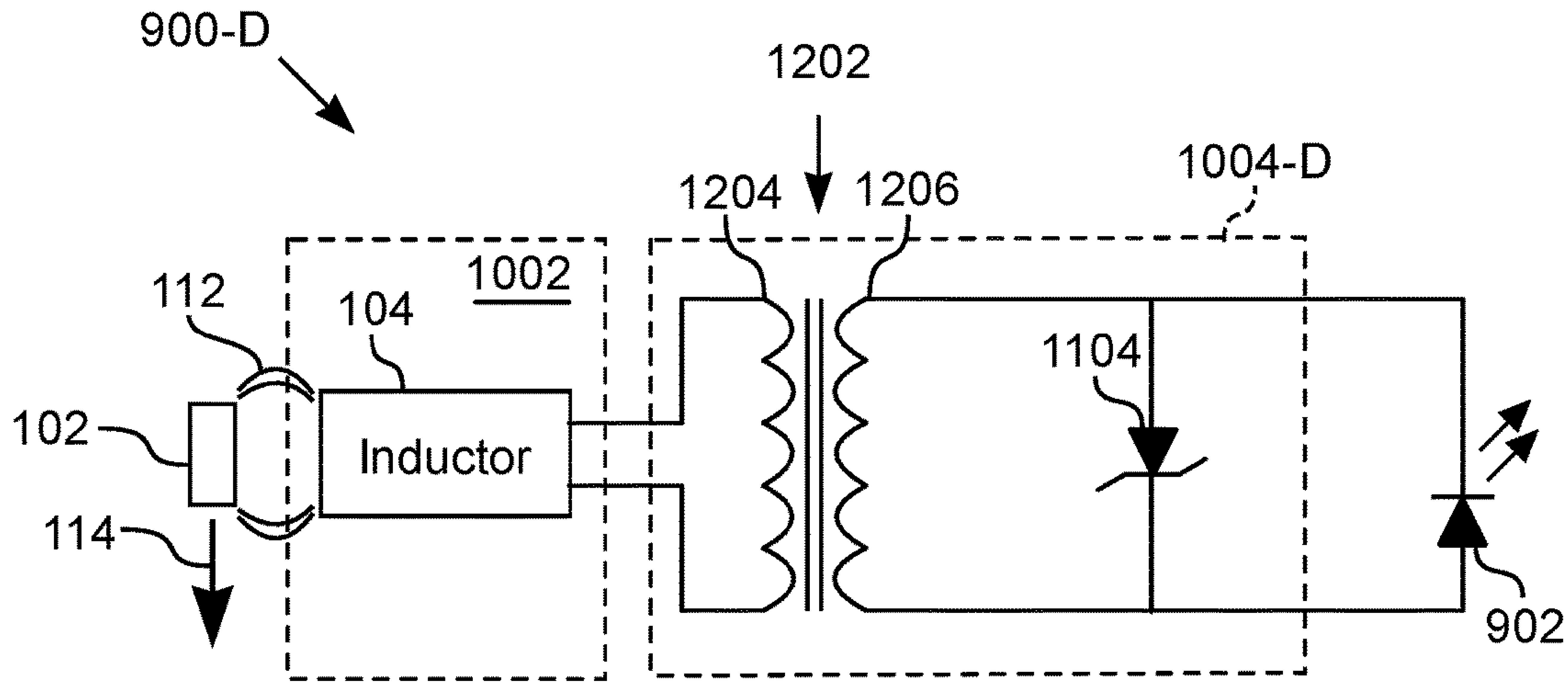

900-D
1202
1204
1206
1004-D
1002
112
104
1104
102
Inductor
114
902

Fig. 12

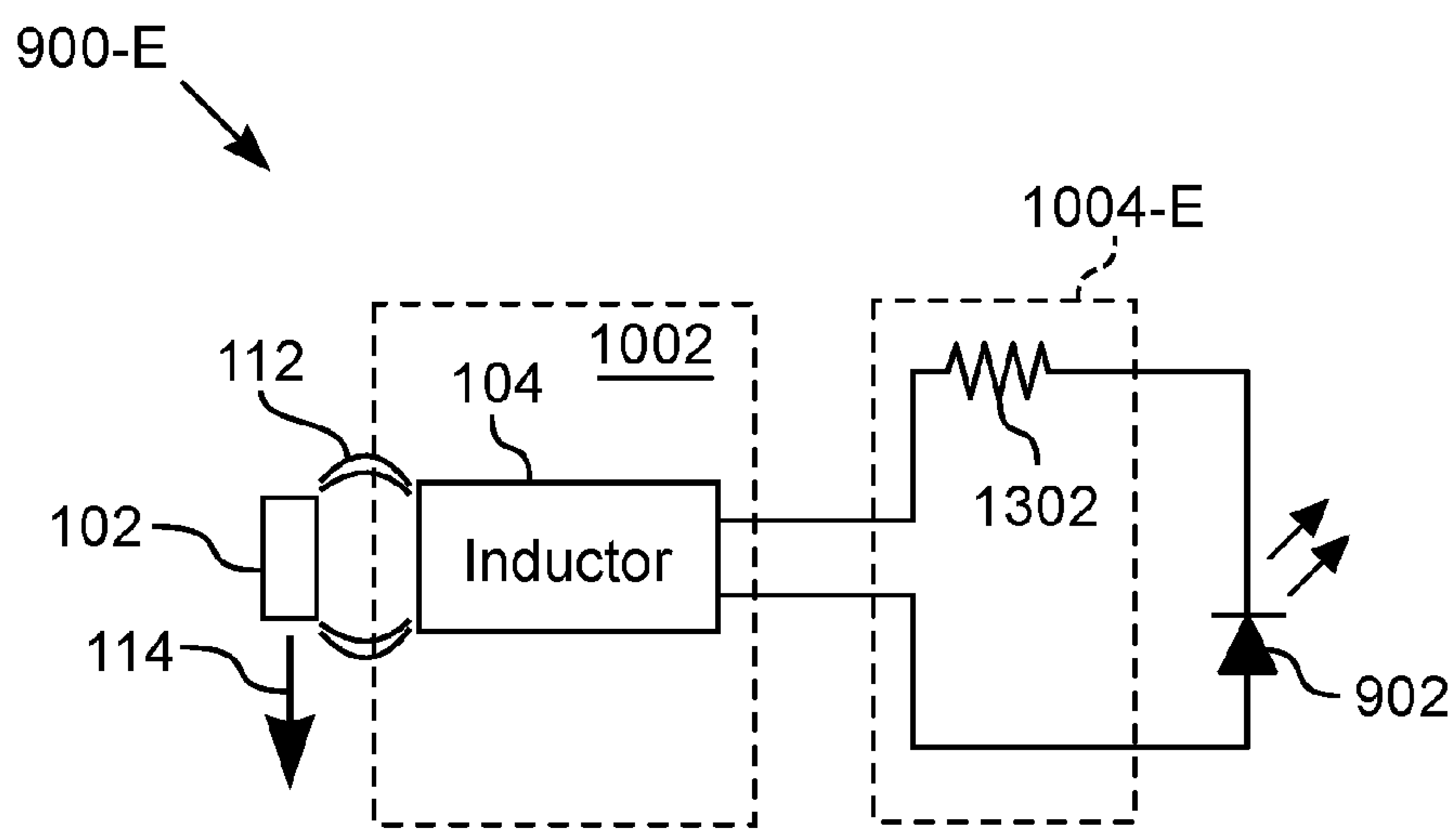

900-E
1004-E
1002
112
104
102
Inductor
1302
114
902

Fig. 13

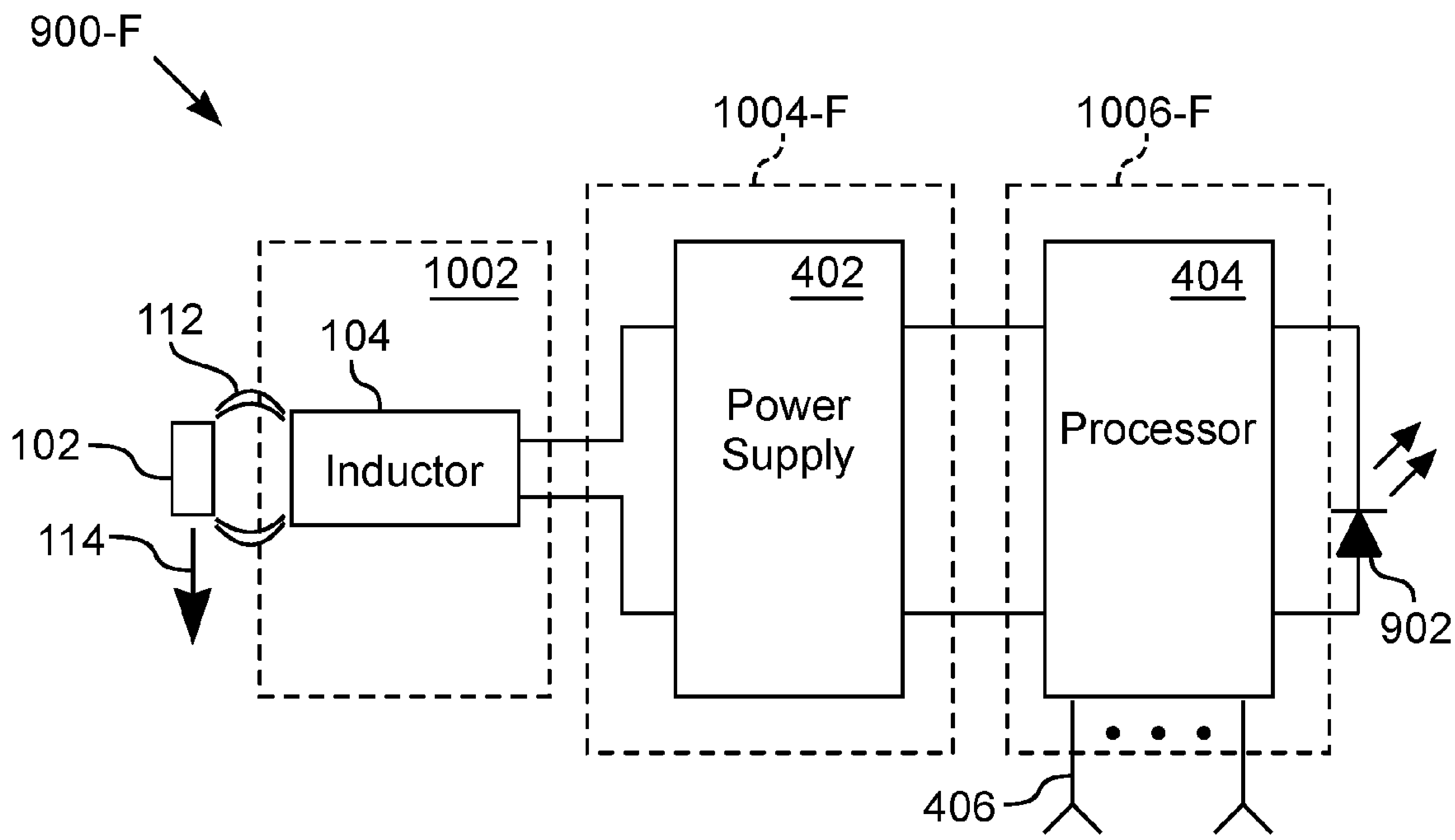

900-F
1004-F
1006-F
1002
402
404
112
104
Power
Supply
Processor
102
Inductor
114
902
406

Fig. 14

SELF POWERED OPTICAL SYSTEM

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND

This invention pertains to a self-contained monitoring system with a self-powered optical transmitter. More particularly, this invention pertains to a self-powered transmitter that is responsive to repetitive magnetic interactions to transmit optical signals to a remote receiver.

DESCRIPTION OF THE RELATED ART

Rotating and moving machines are in widespread use. With rotating machines, rotational speed is often desired to be measured. Rotational speed provides information on how fast the machine is rotating, and depending upon the configuration, on the speed of a downstream component. With reciprocating or linear machines, such as piston operated machines and conveyors, the time between oscillations or the time the machine takes to move from one point to another provides useful information.

In many environments, the machine information is desired to be used at a location remote from the machine. Traditionally, a sensor or instrument is mounted on or next to the machine and wiring is needed to provide power to the sensor and/or to send a signal from the sensor to a remotely mounted monitor. In an automobile, wiring from a sensor measuring engine speed and/or tire rotational speed adds complexity and cost during manufacturing and maintenance because of the constraints inherent in a vehicle. In industrial applications, wiring from sensors on rotating, reciprocating, and linear machines adds complexity and costs because of the environment and distance between such equipment and the remote monitoring equipment.

Traditional sensors and instruments need a power source, either independent or as part of the signal circuit. Independent power supplies create reliability problems for the instrumentation system because the instrumentation power source is typically independent of the power source for the machine being monitored. Oftentimes, wireless communications in industrial environments are not practical because of the electromagnetic interference (EMI) from plant equipment. Wireless communication uses electromagnetic waves to carry information. The EMI interferes with the electromagnetic waves, often causing information loss.

BRIEF SUMMARY

According to one embodiment of the present invention, a self-powered optical transmitter system is provided. The self-powered optical transmitter system is a self-contained monitoring system that has no need for external wiring for a power source and does not rely upon a battery that must be replaced or requires maintenance.

The self-powered optical transmitter system includes a magnet and a transmitter that is responsive to the magnet. The magnet is dimensioned and configured to be attached to a moving component of a machine. The magnet is dimensioned to be have a short interaction time compared to a dwell time where the magnet does not interact with the transmitter. In one embodiment, the transmitter includes an inductor, a power converter, an optical driver, and an optical transducer. The optical transducer is powered from the energy generated by the inductor. The power converter has an input connected to the inductor and produces power at a level suitable for powering the transmitter. A discrete optical driver is used, if needed, to provide an interface between the power converter and the optical transducer.

In one such embodiment, the optical transmitter includes an inductor responsive to a moving magnet, a power converter that increases the voltage generated by the inductor, a processor powered by the power converter, and an optical transducer that is driven and modulated by the processor. The processor has one or more inputs. The processor outputs a data stream identifying the transmitter and containing information related to each processor input.

In another type of self-powered transmitter system, the transmitter includes an inductor, a delay circuit, and an optical transmitter with an antenna. The magnet interacting with the inductor generates sufficient power to transmit a signal corresponding to the time that the magnet interacts with the inductor. Precise timing is insured by the inductor connected to the trigger input of the transmitter unit and the delay circuit adding a short delay of the signal applied to the trigger input with the delayed signal connected to the supply voltage connection of the transmitter. The transmitter transmits a signal upon being energized because the trigger is already at its trigger voltage when the transmitter unit is energized with enough power to transmit. The transmitter outputs a pulse to an antenna every time the magnet engages the coil. In this way, the single sensor burst transmitter system is self-powered and has a minimum number of components.

In one embodiment, the magnet passing by an inductor coil induces a current/voltage spike in the inductor. One end of the coil is electrically connected to a reference, common, or ground on the transmitter and to one end of an RC (resistance-capacitance) network that is also connected to the supply voltage connection of the transmitter. The other end of the coil is connected to the trigger input on the transmitter. The transmitter is powered and triggered by the magnet interacting with the coil, thereby transmitting a pulse from an antenna attached to the transmitter. In various embodiments, one or more magnets are attached to a moving part of the machine.

In various embodiments, the single sensor burst transmitter system senses a parameter of a vehicle or machine, such as motor or engine revolutions per minute (RPM) or the vehicle speed, and transmits data representing that parameter. In one such embodiment, the system includes a magnet positioned on a rotating or moving component of a vehicle, such as a shaft, fan belt pulley, flywheel, or drive shaft. In another embodiment, the system senses a parameter of a machine, such as a pump, a motor, or conveyor. Examples of the monitored parameter include rotational speed, rate of reciprocation, belt speed, or other cyclical motion that positions one or more magnets spatially at a fixed location with a frequency that is measured.

The magnet is magnetically coupled to an inductor when the magnet moves past the inductor. The magnetic coupling induces a voltage/current spike in the inductor. The inductor is connected between the reference or common and the trigger of the transmitter. The inductor is also connected to a delay, or resistor-capacitor tank circuit, that is connected to the supply voltage connection of a transmitter. The inductor supplies a trigger signal to the transmitter before the transmitter receives sufficient power from the inductor to turn on. The voltage spike from the inductor interacting with the magnet causes the transmitter to send a wireless pulse from an antenna connected to the transmitter. The transmitted pulses are sensed by a receiver that is responsive to the wireless signal.

In one embodiment, multiple single sensor burst transmitter systems are employed. Each one of the burst transmitter systems monitors a different parameter or different machine. Each one of the burst transmitter systems transmits at a different frequency or channel or with a different type of modulation. In this way, multiple parameters are monitored.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The above-mentioned features will become more clearly understood from the following detailed description read together with the drawings in which:

FIG. **1** is a functional block diagram of one embodiment of a single sensor burst transmitter system.

FIG. **2** is a schematic diagram of one embodiment of a single sensor burst transmitter system.

FIG. **3***a* is a diagram showing the trigger signal applied to the transmitter unit over time.

FIG. **3***b* is a diagram showing the Vcc voltage applied to the transmitter unit over time.

FIG. **3***c* is a diagram showing the pulse signal sent to the antenna over time.

FIG. **4** is a functional block diagram of one embodiment of a multi-sensor transmitter system.

FIG. **5** is a schematic diagram of one embodiment of a power supply.

FIG. **6** is a functional block diagram of one embodiment of a wireless tachometer system.

FIG. **7** is a schematic diagram for one embodiment of a signal conditioner.

FIG. **8** is a schematic diagram for another embodiment of a signal conditioner.

FIG. **9** is a schematic diagram of one embodiment of a self-powered optical system.

FIG. **10** is a block diagram of an embodiment of a self-powered optical transmitter.

FIG. **11** is a schematic diagram of third embodiment of a self-powered optical transmitter.

FIG. **12** is a schematic diagram of fourth embodiment of a self-powered optical transmitter.

FIG. **13** is a schematic diagram of fifth embodiment of a self-powered optical transmitter.

FIG. **14** is a schematic diagram of sixth embodiment of a self-powered optical transmitter.

DETAILED DESCRIPTION

Apparatus for a self-powered optical transmitter **900** is disclosed. The self-powered optical transmitter **900** senses and transmits a parameter associated with a machine or device that has cyclic or reciprocating movement. The self-powered optical transmitter is generally indicated as **900** with specific embodiments identified with a suffix, such as **900**-A, **900**-B, **900**-C, etc.

FIG. **1** illustrates a functional block diagram of one embodiment of a single sensor burst transmitter system **10**. The system **10** includes a magnet **102** and a burst transmitter **100**. The magnet **102**, in one embodiment, is attached to a moving object such that the magnet **102** periodically moves past the burst transmitter **100**. The burst transmitter **100** interacts with the magnet **102** and transmits a pulse **306** each time the magnet **102** passes by the burst transmitter **100**.

The burst transmitter **100** includes an inductor **104**, a delay **106**, and a transmitter **108** that is connected to an antenna **110**. The magnetic field **112** of the magnet **102** engages the inductor **104** when the magnet **102** moves past the inductor **104**. The magnetic field **112** of the magnet **102** interacts with the inductor **104** and induces a pulse **302** in the inductor **104**.

The magnet **102** is secured to a part of a machine that moves in at least one direction **114** relative to the inductor **104** in the burst transmitter **100**. The magnet **102**, through the magnetic field interaction with the burst transmitter **100**, provides the energy that powers the burst transmitter **100**. Also, the magnet **102** triggers the burst transmitter **100** to transmit the signal **306** when the magnet **102** is proximate the inductor **104**. Although the illustrated embodiment depicts the magnet **102** as moving in direction **114**, it is the relative motion between the magnet **102** and the inductor **104** that is relevant. For example, in another embodiment, the burst transmitter **100** is attached to the moving component and the magnet **102** is stationary.

The magnet **102** is dimensioned relative to the moving part of the machine such that the magnetic field **112** is substantially a point source that engages the inductor **104** for a shorter duration than the duration when the magnetic field **112** does not engage the inductor **104**. That is, the interaction of the magnetic field **112** with the inductor **104** occurs briefly compared to the long dwell time with no interaction by the magnetic field **112**. The interaction of the magnetic field **112** occurs during an interaction interval, which can be expressed in units of time or angular displacement. The dwell interval refers to the time or angular displacement where the magnetic field **112** does not interact with the inductor **104**. For those embodiments where a magnet **102** is attached to a moving component of a machine, the magnet **102** will be substantially smaller than the moving component in order to minimize the mass added to the moving component and to minimize any unbalancing effect from the addition of the magnet **102**. Typically, the ratio of the interaction interval to the dwell interval will be about 1:10 or less. For example, in one embodiment, the magnet **102** is cylindrical and less than ½ inch in diameter. The magnet **102** is attached to a rotating pulley that is six inches in diameter. In this example the interaction interval is approximately 10 degrees or less and the dwell interval is approximately 350 degrees or more, which results in the ratio of the interaction interval to the dwell interval of 10:350.

The magnet **102** is attached to a moving component that moves in a cyclical or repetitive manner such that the magnet **102** repeatedly moves proximate the inductor **104** at an interval that corresponds to some variable to be measured, such as revolutions per minute (RPM). For example, in one embodiment, the magnet **102** is attached to a shaft of a pump or motor. The magnet **102** moves in direction **114** as the shaft rotates. The rate of interactions of a single magnet **102** on the shaft with the inductor **104** provides data on the rotational speed of the shaft. One interaction between the magnet **102** and inductor **104** corresponds to one revolution of the shaft.

For slower moving devices, multiple magnets **102** are spaced at regular intervals and an appropriate scaling factor is applied to the sensed rate of interactions to determine the rate of movement. For example, a plurality of magnets **102** are attached to a conveyor belt at regular intervals to measure the speed of the conveyor belt. Each time a magnet **102** moves proximate the inductor **104** the burst transmitter **100** transmits a pulse **306**. Either the time difference between pulses **306** or the number of pulses **306** per unit of time are used to determine the speed of the conveyor belt.

The inductor **104** is responsive to the magnetic field **112** of the magnet **102**. The leads of the inductor **104** are connected to the transmitter **108**. The interaction of the magnetic field **112** of the magnet **102** with the inductor **104** causes the inductor **104** to generate a pulse **302** that sets the trigger Tr of the transmitter **108**.

The delay **106** is connected between the reference or ground Ref of the transmitter **108** and the supply voltage Vcc connection of the transmitter **108**. The delay **106** adds a short time delay to the pulse **302** from the inductor **104**.

The transmitter **108** is a device that transmits a wireless signal through an antenna **110**. In one embodiment, the transmitter unit **108** causes a wireless radio frequency (RF) signal to be sent from the antenna **110**. The transmitter unit **108** is both powered and triggered by the magnetic field **112** of the magnet **102** interacting with the inductor **104**. When multiple single sensor burst transmitter systems **10** are used within range of a single receiver, the transmitters **108** are configured to minimize or reduce interference. For example, in one embodiment, each transmitter **108** operates at a specific frequency or channel different from other transmitters **108**.

FIG. **2** illustrates a schematic diagram of one embodiment of a single sensor burst transmitter system **10**. The illustrated embodiment of the transmitter system **10** includes a magnet **102** and a burst transmitter **100**. The burst transmitter **100** includes an inductor **104**, a delay circuit **106**, a transmitter **108**, and an antenna **110**.

In one embodiment, the magnet **102** is secured to a moving part of a machine. The magnet **102** moves in a direction **114** relative to the inductor **104**. Because the magnet **102** adds mass to the moving part, the magnet **102** in one embodiment is a rare earth magnet, which ensures the size is minimized and the magnetic field generated is as strong as possible relative to the size of the magnet **102**. In another embodiment, the burst transmitter **100** is secured to the moving part of the machine and the magnet **102** is stationary.

The inductor **104** is a coil that is responsive to the magnetic field **112** of the magnet **102**. In various embodiments, the inductor **104** is an air wound coil or a cored inductor. The inductor **104** is oriented such that the magnetic field **112** passing through the inductor **104** generates sufficient power to drive the transmitter **108**.

The delay **106** includes an RC circuit with a resistor **202** and capacitor **204** connected in parallel. The RC circuit **106** is connected between the reference, common, or ground Ref of the transmitter **108** and the supply voltage Vcc connection of the transmitter **108**. The delay circuit **106** adds a short delay to the voltage generated by the inductor **104** and applies that delayed signal **304** to the supply voltage Vcc connection of the transmitter unit **108**. The values for the resistor **202** and the capacitor **204** in the RC circuit **106** are selected such that the voltage across the capacitor **204** falls below the minimum required Vcc voltage **312** within the period **324** between trigger pulses **304**. That is, the time to drain the capacitor **204** is less than the period **324** being measured.

The transmitter **108** is a low power device with a fast response time that is operable with the amount of power generated by the magnet **102** moving relative to the inductor **104**. The transmitter **108** has a trigger input Tr that causes the transmitter **108** to output a signal from the antenna output ANT to the antenna **110** when the trigger input Tr is at or above a trigger voltage **312**. In various embodiments, the antenna **110** is an external or built-in antenna operating at the frequency of the transmitter **108**.

In one example, the transmitter **108** is an amplitude modulated (AM) hybrid transmitter unit, such as the Model AM-RT4-315 sold by RF Solutions. The transmitter unit **108** is a complete, self-contained RF transmitter that supports a transmitted data rate up to about 4 kHz. The transmitter unit **108** requires a supply voltage (Vcc) of between 2 and 14 volts dc with a typical supply current of 4 mA at 5 Vdc. The minimum input level is 2 volts dc with a maximum equal to Vcc. The transmitter unit **108** operates at a fixed frequency of 315 MHz with a range up to 70 meters. The transmitter unit **108** has four leads: supply voltage Vcc, reference or ground Ref, trigger input Tr, and output for an external antenna Ant. The transmitter unit **108** has an equivalent circuit capacitance of 1 nF between the trigger input Tr and the supply voltage Vcc connections, and an equivalent circuit capacitance of 100 pF between the ground Ref and the trigger input Tr connections and between the ground Ref and the supply voltage Vcc connections.

In such an example, the supply voltage Vcc signal **304** is delayed approximately 0.6 milliseconds relative to the signal **302** applied to the trigger input Tr of the transmitter unit **108**. Such a delay is sufficient to ensure that the transmitter unit **108** transmits a signal **306** as soon as the supply voltage Vcc signal **304** is at a level sufficient to power the transmitter unit **108**. That is, with the trigger input Tr at a voltage at or above the required trigger voltage **312**, the transmitter **108** outputs a signal as soon as the Vcc voltage reaches the minimum required Vcc voltage **314**. With the transmitter unit **108** in this example, the minimum trigger input Tr and the minimum supply voltage Vcc are the same, which is 2 volts. In the tested embodiment, the magnet **102** and inductor **104** combination produce a spike of 2.8 volts, which is sufficient to operate the transmitter unit **108**.

FIG. **2** illustrates a simplified schematic of one embodiment of a single sensor burst transmitter system **10**. The simplified schematic does not illustrate various connections that may be required to accommodate specific components selected, for example, the transmitter unit **108** may require a crystal or other frequency selection circuitry. An antenna tuning or matching circuit may also be needed depending upon the components selected. Those skilled in the art will recognize the need for such wiring and understand how to wire such a circuit, based on the components ultimately selected for use.

FIG. **3***a* illustrates a diagram showing the trigger signal **302** applied to the transmitter unit **108** over time t. FIG. **3***b* illustrates a diagram showing the Vcc voltage **304** applied to the transmitter unit **108** over time t. FIG. **3***c* illustrates a diagram showing the output pulse signal **306** sent to the antenna **110** over time t. The output pulse **306** is a signal at the frequency of the transmitter unit **306**, which is much greater than the frequency of magnet **102**—inductor **104** interactions. The output pulse **306** is shown as a square wave because of the magnitude of the frequency difference. The diagrams also illustrate the periodic nature of the signals that correspond to the rate of interaction between the magnet **102** and the inductor **104**. In the illustrated embodiment, the period **324** between spikes or pulses **302**, **304**, **306** is regular.

The inductor **104** generates a voltage spike **302** from the interaction of the magnetic field **112** of the magnet **102** as it moves by the inductor **104**. The inductor **104** is connected between the reference or ground Ref and the trigger input Tr of the transmitter **108** such that the voltage at the trigger input Tr is positive relative to ground Ref. The trigger spike **302** has a maximum voltage that is equal to or greater than the minimum required trigger voltage **312** at the time **310** the output pulse **306** begins. The minimum required trigger voltage **312** is the voltage level required by the trigger input Tr of the transmitter **108** to send a signal.

The delay circuit **106** is connected between the reference or ground Ref and the supply voltage Vcc connections of the transmitter **108**. The RC circuit **106** adds a short delay to the voltage spike **302** from the inductor **104** such that the supply voltage **304** reaches a level **310** sufficient to power the transmitter **108** after the trigger input Tr has reached a sufficient level to trigger the transmitter **108** to send a pulse **306**. The minimum required Vcc level **314** is the voltage level required by the transmitter **108** to be energized and operable.

The Vcc voltage **304** enables the transmitter **108** to operate when the Vcc voltage **304** reaches the minimum required Vcc voltage **314** at time **310**. A first vertical line **310** shows the relationship between when the Vcc voltage **304** reaches the minimum required Vcc voltage **314** and the other signals **302**, **306**.

Referring to FIG. **3***a*, the trigger spike **302** has a voltage that is equal to or greater than the minimum required trigger voltage **312** at the time **310** the Vcc voltage **304** reaches the minimum required Vcc voltage **314**. Because these two conditions are met (trigger voltage **302** at or greater than minimum trigger voltage **312** and Vcc voltage **304** at or greater than minimum required Vcc voltage **324**), the transmitter unit **108** sends an output pulse **306** starting at time **310**.

The second vertical line **320** shows the relationship between when the trigger signal **302** falls below the minimum required trigger voltage **312** and the other signals **304**, **306**. The output pulse **306** ends at the time **320** when the trigger signal **302** falls below the minimum required trigger voltage **312** or the Vcc voltage **304** falls below the minimum required Vcc voltage **314**, whichever occurs first. In the illustrated diagrams, the output pulse **306** stop time **320** occurs when the trigger signal **302** falls below the minimum required trigger voltage **312**. The time width of the Vcc voltage signal **304** at the minimum required Vcc voltage **324**, minus the amount of time delay introduced by the RC circuit **106**, determines the width of the output pulse **306**. that is, the width of the pulse **306** is the time between the pulse start time **310** and end time **320**.

FIG. **4** illustrates a functional block diagram of one embodiment of a multi-sensor transmitter system **40**. The multi-sensor transmitter system **40** includes a magnet **102** that interacts with a multi-sensor transmitter **400**. The multi-sensor transmitter **400** includes an inductor **104** connected to a power supply **402** that is connected to a processor **404** and a transmitter **108**. The inductor **104**, when it interacts with the magnetic field **112** of the magnet **102**, is a power source for the power supply **402**. The power supply **402** provides power to the processor **404** and the transmitter **108**. The processor **404** has a multitude of inputs **406**, for example, inputs from sensors such as switches and transducers. The transmitter **108** has an input from the processor **404** and an output connected to an antenna **110**.

As with the single sensor burst transmitter system **10**, the magnet **102** moves repetitively relative to the inductor **104**. In one embodiment, the magnet **102** is attached to a machine part that reciprocates or rotates such that the magnet **102** periodically moves past the inductor **104** in direction **114**. The magnet **102** has a magnetic field **112** that periodically interacts with the inductor **104** to produce a pulse **302** in the inductor **104**. In one embodiment, multiple magnets **102** are attached to the machine such that the inductor **104** senses the magnetic field **112** at a rate greater than once per cycle or revolution. In this way the multi-sensor transmitter **400** remains functional with machines that have a low reciprocating rate or a low number of revolutions per second.

The magnet **102** is dimensioned relative to the moving part of the machine such that the magnetic field **112** is substantially a point source that engages the inductor **104** for a shorter duration than the duration when the magnetic field **112** does not engage the inductor **104**. That is, the interaction of the magnetic field **112** with the inductor **104** occurs briefly compared to the long dwell time with no interaction by the magnetic field **112**. The interaction of the magnetic field **112** occurs during an interaction interval, which can be expressed in units of time or angular displacement. The dwell interval refers to the time or angular displacement where the magnetic field **112** does not interact with the inductor **104**. For those embodiments where a magnet **102** is attached to a moving component of a machine, the magnet **102** will be substantially smaller than the moving component in order to minimize the mass added to the moving component and to minimize any unbalancing effect from the addition of the magnet **102**. Typically, the ratio of the interaction interval to the dwell interval will be about 1:10 or less. For example, in one embodiment, the magnet **102** is cylindrical and less than ½ inch in diameter. The magnet **102** is attached to a rotating pulley that is six inches in diameter. In this example the interaction interval is approximately 10 degrees or less and the dwell interval is approximately 350 degrees or more, which results in the ratio of the interaction interval to the dwell interval of 10:350.

The processor **404** includes one or more inputs **406**. The processor **404** outputs a signal to the transmitter **108** that includes an identifier and data. The identifier uniquely identifies the multi-sensor transmitter **400** for the embodiment where several transmitters **400** are used concurrently with overlapping range. In this way a receiver is able to identify the transmitter **400** and its corresponding data. The data corresponds to the inputs **406** to the processor **404**.

As used herein, the processor **404** should be broadly construed to mean any computer or component thereof that executes software. The processor **404** includes a memory medium that stores software, a processing unit that executes the software, and input/output (I/O) units for communicating with external devices. Those skilled in the art will recognize that the memory medium associated with the processor **404** can be either internal or external to the processing unit of the processor without departing from the scope and spirit of the present invention.

In one embodiment the processor **404** is a general purpose computer, in another embodiment, it is a specialized device for implementing the functions of the invention. Those skilled in the art will recognize that the processor **404** includes an input component, an output component, a storage component, and a processing component. The input component receives input from external devices, such as the switches, sensors, and instruments that can be connected to the inputs **406**. The output component sends output to external devices, such as the transmitter **108**. The storage component stores data and program code. In one embodiment, the storage component includes random access memory. In another embodiment, the storage component includes non-volatile memory, such as floppy disks, hard disks, and writeable optical disks. The processing component executes the instructions included in the software and routines.

When multiple multi-sensor transmitter systems **40** are used within range of a single receiver, the transmitters **108** are configured to minimize or reduce interference. For example, in one embodiment, each transmitter **108** operates at a specific frequency or channel different from other transmitters **108**. In another embodiment, the multiple transmitters **108** operate on the same frequency and the received signals are differentiated by the identifier sent by the transmitter **400**. Because the signal has a short duration compared to the time between transmitted signals, collisions are rare. In case of a collision of signals from two transmitters **400**, the next set of transmitted signals should not collide because the difference in the rotational speed of the magnet **102** is sufficiently different to cause the transmitters **400** to transmit at different times, assuming the transmission rate is tied to the rotational speed of the magnet **102**.

FIG. **5** illustrates a simplified schematic diagram of one embodiment of a power supply **402**. The power supply **402** includes an energy harvester, or voltage multiplier, **522**, a storage circuit **524**, and a voltage regulating circuit **526**.

The magnet **102** moves periodically in a direction **114** that causes the magnet's flux **112** to induce a current in the inductor **104**. The strength of the magnetic flux **112** and the speed of the magnet **102** as it moves past the inductor **104** influence the magnitude and shape of the induced current signal. In various embodiments, the voltage across the inductor **104** due to the induced current is selected by using a transformer or by adjusting the configuration of the inductor **104**. In one embodiment, the inductor **104** has a length parallel to the magnet direction **114** that is sufficient to produce the desired power from the interaction of the inductor **104** with the magnetic field **112** of the magnet **102**.

The inductor **104** is a coil that is positioned near where the magnet **102** moves. The leads of the inductor **104** are connected to the power supply **402**, which has an energy harvester **522**, a storage circuit **524**, and a voltage regulating circuit **526**. In the illustrated embodiment, the energy harvester **522** in the power supply **402** is a voltage multiplier. The voltage multiplier circuit **522** increases the voltage across the inductor **104** to a level suitable for use by the processor **404** and the transmitter **108**. The voltage multiplier circuit **522** includes a network of capacitors **502**, **506** and diodes **504** that has an output voltage **516**, **512** that is greater than the input voltage of the inductor **104**. The voltage multiplier circuit **522** charges the capacitor **508** in the storage circuit **524**.

The storage unit **524** stores the energy from the inductor **104** at the output voltage **516**, **512** of the voltage multiplier circuit **522**. In the illustrated embodiment the storage unit **524** is a capacitor **508**. The capacitor **508** has a voltage rating sufficient to accommodate the maximum voltage from the voltage multiplier circuit **522**. The capacitor **508** has sufficient capacitance to store the energy from the periodic interactions of the magnet **102** with the inductor **104**, considering the power needs of the processor **404** and the transmitter **108**.

The capacitance of the capacitor **508** affects the power storage capability and the start up time before such capacity is available. A capacitor **508** with high capacitance, for example, 0.33 F, requires several minutes from a cold start before being fully charged by the interaction of the magnetic field **112** with the inductor **104**. Once charged, the capacitor **508** is able to provide power for substantial periods and/or power levels. A capacitor **508** with lower capacitance, for example, 0.022 F, is smaller in size, quicker to provide power after a cold start, and provides power for shorter periods and/or at lower power levels.

The voltage regulating circuit **526** in the illustrated embodiment includes a series of light emitting diodes (LEDs) **410**. The LEDs **410**, across the storage capacitor **508**, serve to regulate the voltage output of the power supply **402**. Red LEDs have a forward voltage of between 1.6 and 2.0 volts, depending upon the doping of the LED. For example, an output voltage of approximately 5 volts can be obtained with three LEDs between the ground **516** and the second output **512**. An output voltage of approximately 3.2 volts can be obtained with two LEDs between the ground **516** and the first output **514**. Until the output capacitor **508** is charged, the output voltages **512**, **514** will be less than the voltage drop across the LEDs **510**. The forward current through the LEDs **510** is limited because the current from the inductor **104** and the voltage multiplier circuit is limited. Another embodiment of the voltage regulating circuit **526** uses a Zener diode to control the output voltage **512**, **514**. In various embodiments, one or both of the outputs **512**, **514** are used, based on the needs of the processor **404** and transmitter **108**.

Upon first starting up, the power supply **402** has a zero output voltage. As the magnet **102** interacts with the inductor **104**, the voltage multiplier circuit **522** charges the capacitor **508** in the storage unit **524** to the sum of the forward voltages of the diodes **510** in the voltage regulator circuit **526**. The voltage regulator circuit **526** maintains a relatively constant voltage until current is drawn through the power supply **402**. The voltage output **512**, **514** remains somewhat constant until the output current level increases to the level where the capacity of the inductor **104** and voltage multiplier circuit **522** to keep the storage unit **524** charged is exceeded. The output voltage **512**, **514** then falls. With an increasing load, that is, with a decreasing load impedance, when the output current level reaches a level where the magnet-inductor **102**, **104** interaction cannot supply the full energy requirement, the output voltage **512**, **514** drops, as does the current. The output voltage **512**, **514** recovers only when the load decreases, that is, when the load impedance increases.

FIG. **5** illustrates a simplified schematic of one embodiment of a power supply **402**. The simplified schematic does not illustrate various connections and components that may be required to accommodate specific components selected and/or desired circuit specifications. For example, the number of capacitors **502**, **506** and diodes **504** in the voltage multiplier circuit **522** depend upon the desired output voltage and power desired at the output **512**, **514**. In another example, the size of the capacitor **508** in the storage unit **524** will vary depending upon the desired start time (larger capacitance requires a greater charging time upon startup) and the power desired for the transmitter **108** (larger capacitance allows for greater energy storage).

FIG. **6** illustrates a functional block diagram of one embodiment of a wireless tachometer system **60**. The wireless tachometer system **60** includes a tachometer receiver circuit **600** and a conventional tachometer **608**. The tachometer receiver circuit **600** is responsive to a wireless signal from a transmitter **108** that sends pulses corresponding to a rotational speed of a device. In various embodiments, the transmitter **108** is one in a single sensor burst transmitter system **10**, a multi-sensor transmitter system **40**, a wireless system such as described in U.S. Pat. No. 8,035,498 (hereby incorporated by reference), or another wireless system that monitors a rotating device.

The tachometer receiver circuit **600** includes an antenna **602**, a receiver **604**, and a signal conditioner **606**. The antenna **602** and receiver **604** detect the pulses corresponding to the rotational speed of a device desired to be monitored. The signal conditioner **606** is a circuit that converts the output of the receiver **604** into a signal that is compatible with a conventional tachometer **608**. The wireless tachometer **60** monitors engine speed in a vehicle with a wireless connection between the sending unit and the wireless tachometer **60**.

Typically, vehicles operate with a voltage of 12 Vdc. Wireless receivers **604** provide an analog output signal at half the supply voltage because the receiver output is an ac signal that, at most, fluctuates peak-to-peak between −6 and +6 volts, which is a range of 12 volts but with a maximum voltage of half of the operating voltage. The nominal maximum output of 6 volts for the receiver **604** is reduced further because of the level of the wireless signal fluctuates under normal conditions and receivers **608** are not intended to be operated at maximum gain for long term use. Accordingly, the conventional receiver **604** operating at a 12 volt rail voltage has an output substantially less than 6 volts. For example, a 10 db reduction from maximum, which is not normally considered a substantial reduction, results in an output level of 0.6 volts, which is insufficient to drive a conventional tachometer **608**.

Conventional tachometers **608** require an input signal of 12 Vdc pulses because the conventional tachometer **608** is configured to be connected directly to the vehicle's coil or a tach output on an electronic ignition. The output of conventional receivers **604** are not compatible with the input of conventional tachometers **608**. To correct the mismatch of voltage levels, a signal conditioner **606** matches the output of the conventional receiver **604** to the input of the conventional tachometer **608**. Without the signal conditioner **606**, the conventional tachometer **608** cannot provide a reliable indication with only the output of the conventional receiver **604**.

In one embodiment, the wireless tachometer system **60** functions with a wireless input corresponding to a signal with two pulses per revolution and with the conventional automotive tachometer **608** configured with a setting corresponding to a **6** cylinder engine. The two pulses received for the wireless input correspond to a wireless transmitter sensing two magnets on the rotating member for one revolution. For those conventional automotive tachometers **608** that include a pulse per revolution (PPR) setting, the tachometer PPR setting is adjusted to correspond to the number of magnets **102** used.

FIG. **7** illustrates a schematic diagram for one embodiment of a signal conditioner **606**-A for a wireless tachometer system **60**. In the illustrated embodiment, an operational amplifier (op amp) **702** conditions the output signal **708** from the receiver **604** into a signal that is compatible with the tachometer **608**. The capacitor **704** and variable resistor **706** are connected across the gain connections of the op amp **702** to control the level of the output **710**.

In one such embodiment, the op amp **702** is an LM386, the capacitor **704** is 10 μF, and the resistor **706** is 10K ohms. In another embodiment, the op amp **702** is an LM4861 and the resistor **706** is not used. The input **708** to the signal conditioner **606**-A is the low voltage output of the receiver **604**. That is, the input **708** to the signal conditioner **606**-A is at a nominal maximum of 6 volts. The gain of the signal conditioner **606**-A is such that the output **710** is at a nominal 12 Vdc, which is sufficient to trigger the conventional automotive tachometer **608** reliably. In one such embodiment, the operational amplifier functions as a comparator with the gain set to minimize overdriving the operational amplifier while avoiding saturation.

FIG. **8** illustrates a schematic diagram for another embodiment of a signal conditioner **606**-B. In the illustrated embodiment, a step up transformer **802** is used to convert the input **708** to the output **710**. In one such embodiment, the transformer **802** is a step up transformer with a turns ratio of 3:1 or greater. In one such embodiment, the transformer **802** has a turns ratio of at least 5:1.

The input **708** to the signal conditioner **606**-B is the low voltage output of the receiver **604**, which is at a nominal maximum of 6 volts. The ratio of the transformer **802** is such that the output **710** is at a nominal 12 Vdc, which is sufficient to trigger the conventional automotive tachometer **608** reliably.

The output of the conventional receiver **604** is an alternating current (ac) signal. The transformer **802** steps up the receiver output voltage to a level that ensures reliable operation of the conventional tachometer **608**. In one such embodiment, the gain of the receiver **604** is set or adjusted so that the output of the transformer **802** is at or near the operating voltage of the vehicle. In another such embodiment, the turns ratio of the transformer **802** is selected such that the output of the transformer **802** is at or near the operating voltage of the vehicle considering the output of the receiver **604**. For installations where the transmitted signal strength is fixed and with a receiver **604** having a fixed gain, the transformer ratio is selected to provide an output that is greater than the minimum voltage requirement of the tachometer **608** and less than the saturation or maximum voltage of the tachometer **608**.

FIGS. **7** and **8** illustrate simplified schematics of the signal conditioners **606**-A, **606**-B. The simplified schematics do not illustrate various connections that may be required to accommodate specific components selected.

FIG. **9** illustrates a schematic diagram of one embodiment of an optical system **920**. The optical system **920** includes a self-powered optical transmitter **900**-A and an optical receiver **910**. The illustrated self-powered optical transmitter **900**-A is suitable for applications where a magnet **102** interacts with the inductor **104** at a mid-range frequency. At the mid-frequency range the magnet **102** moves past the inductor **104** at a speed fast enough to induce an electromagnetic force (EMF) sufficient to power the optical transducer **902**.

The self-powered optical transmitter **900**-A includes a magnet **102** attached to a moving object that rotates or reciprocates in a direction **114** past an inductor **104**. The inductor **104** is magnetically coupled **112** with the magnet **102** when the magnet **102** moves proximate the inductor **104**. The magnet **102**, through the magnetic field interaction with the inductor **104**, provides energy to power the light emitting diode (LED) **902**. The LED **902** is an optical transmitter or transducer that emits light at a particular wavelength, for example, the LED **902** emits an infrared signal.

The light emitted by the optical transducer **902** is received by an optical sensor **904**, which is connected to a signal conditioner **906**. The signal conditioner **906** has an output **908** that corresponds to the signal transmitted optically by the transmitter **900**-A. In one embodiment, the output **908** is connected to a tachometer **608**, such as illustrated in FIG. **6**. In other embodiments, the output **908** is connected to equipment that processes or otherwise acts on the received optical signal.

In one embodiment, the optical transducer **902** has a lens that directs the light in a beam. The light beam from the optical transducer **902** is directed toward the optical sensor **904**, which collects the transmitted light. In another embodiment, the optical transducer **902** has a diffuser that spreads the light from the transducer **902**. In this way, the optical sensor **904** is responsive to the optical transmitter **902** without being in a specific direct line. That is, the optical signal is received by the optical receiver **910** even when there is spatial, relative movement between the optical transducer **902** and the optical sensor **904**, provided that there is a clear optical path between the transducer **902** and sensor **906**.

FIG. **10** illustrates a block diagram of an embodiment of a self-powered optical transmitter **900**-B. The optical transmitter **900**-B includes a power collector **1002**, a power converter **1004**, and an optical driver **1006** connected to an optical transducer **906**.

The power collector **1002** is the power source for the optical transmitter **900**-B. The power collector **1002** interacts with the magnet **102** by way of the magnetic field **112** from the magnet **102** as the magnet **102** moves in a direction **114** relative to the power collector **1002**. In one embodiment, the power collector **1002** is an inductor **104** that generates an electromotive force (EMF) from the moving magnetic field **112**. The output of the power converter **1102** is connected to a power converter **1004**.

The power converter **1004** receives the EMF generated from the power collector **1004** and processes or converts that EMF into a power output sufficient to drive the self-powered optical transmitter **900**-B. In the illustrated embodiment, the power converter **1004** has an output connected to an optical driver **1006**. In various embodiments, the power converter **1004** includes a voltage-to-voltage converter or a voltage multiplier, such as a power harvester **522**, a storage circuit **524**, and/or a voltage or power regulating circuit **526**.

The optical driver **1006** is connected to the optical transducer **902**. The optical driver **106** drives the optical transducer **902** to produce the optical signal that communicates with the optical receiver **910**. In various embodiments, the optical driver **1006** is incorporated with the power converter **1004**. That is, the output of the power converter **1004** is sufficient to drive the optical transducer **902** and a separate circuit for an optical driver **1006** is not needed.

FIG. **11** illustrates a schematic diagram of a third embodiment of a self-powered optical transmitter **900**-C. The optical transmitter **900**-C includes a power collector **1002** connected to a power converter **1004**-C that drives an optical transducer **902**. In the illustrated embodiment, the power converter **1004**-C also serves as the optical driver **1006**.

The power converter **1004**-C is a voltage regulating circuit that includes a Zener diode **1104**, which limits the voltage level from the power collector **1002** that is applied to the optical transducer **902**. When the power collector **1002** has an output voltage exceeding a specified voltage level, the diode **1104** conducts, thereby limiting the voltage applied to the optical transducer **902**.

In the illustrated circuit, as the magnet **102** moves past the inductor **104**, the output of the inductor **104** has an increasing voltage, until the voltage reaches the reverse breakdown voltage of the Zener diode **1104**. The optical transducer **902** is a device that emits optical energy, when triggered. The transducer **902** is triggered when the forward voltage reaches a minimum value. With the optical transducer **902** having a forward voltage value slightly less than or equal to the reverse breakdown voltage of the Zener diode **1104** ensures that the optical transducer **902** is triggered when sufficient energy is available from the power collector **1002**. Such a configuration is suitable for use as a tachometer that is subject to very high revolutions per minute (RPM). In such an application, the fast moving magnet **102** creates a quickly changing magnetic field **112**, which excites the inductor **104** to produce a high EMF. The power converter **1004**-C limits or regulates the voltage applied to the optical transducer **902** by that high EMF.

FIG. **12** illustrates a schematic diagram of a fourth embodiment of a self-powered optical transmitter **900**-D. The optical transmitter **900**-C includes a power collector **1002** connected to a power converter **1004**-D that drives an optical transducer **902**. In the illustrated embodiment, the power converter **1004**-D also serves as the optical driver **1006**.

The power converter **1004**-D is a voltage converter or multiplier and a voltage regulator circuit that includes a transformer **1202** and a Zener diode **1104**. The input winding **1204** of the transformer **1202** is connected to the output of the power collector **1002**. The output winding **1206** of the transformer **1202** is connected to the Zener diode **1104**, which is in parallel with the optical transducer **902**. The transformer **1202** has a winding ratio that converts the voltage at the input of the power converter **1004**-D to a voltage level suitable for the optical transducer **902**. In one embodiment, the transformer **1202** is a step-up transformer, that is, the windings **1204**, **1206** are configured such that the voltage at the output winding **1206** is greater than the voltage at the input winding **1204**. The Zener diode **1104** is in the circuit to ensure that the voltage to the optical transducer **902** is limited.

The configuration illustrated in FIG. **12** is suitable for use as a tachometer that is subject to a wide rage of revolutions per minute (RPM). In such an application, at low RPMs the slow moving magnet **102** creates a slowly changing magnetic field **112**, which excites the inductor **104** to produce a low EMF that needs to be increased, which the power converter **1004**-D does. At high RPMs the fast moving magnet **102** creates a quickly changing magnetic field **112**, which excites the inductor **104** to produce a high EMF, which is limited by the Zener diode **1104**.

FIG. **13** illustrates a schematic diagram of a fifth embodiment of a self-powered optical transmitter **900**-E. The optical transmitter **900**-E includes a power collector **1002** connected to a power converter **1004**-E that drives an optical transducer **902**. In the illustrated embodiment, the power converter **1004**-E also serves as the optical driver **1006**.

The power converter **1004**-E is a power regulator circuit that includes a resistor **1302** that is in series with the optical transducer **902**. The resistor **1302** limits the current flowing from the power collector **1002** to the transducer **902**.

FIG. **14** illustrates a schematic diagram of a sixth embodiment of a self-powered optical transmitter **900**-F. The optical transmitter **900**-F includes a power collector **1002** connected to a power converter **1004**-F connected to a optical driver **1006**-F that drives an optical transducer **902**.

The power converter **1004**-F includes a power supply **402** that includes an energy harvester, or voltage multiplier, **522**, a storage circuit **524**, and a voltage regulating circuit **526** such as illustrated in FIG. **5**. In another embodiment, the power converter **1004**-F includes only the energy harvester **522**. In yet another embodiment, the power converter **1004**-F includes the energy harvester **522** and the storage circuit **524**. In one embodiment, the voltage multiplier **522** is a circuit that includes a capacitor-diode network, such as a half-wave series multiplier.

The output of the power converter **1004**-F is connected to the input of the optical driver **106**-F. The optical driver **1006**-F includes a processor **404** that is powered by the output of the power converter **1004**-F. The processor **404** includes one or more inputs **406** that are controlled by the processor **404** to send a specific signal to drive and/or modulate the optical transducer **902** to send a specific signal corresponding to the inputs **406**. The illustrated embodiment of the optical transmitter **900**-F accommodates multiple sensors with the power for the optical transmitter **900**-F provided by the magnet **102** moving past the power collector **1002**. In one embodiment, an input **406** to the processor **404** corresponds to the event of the magnet **102** moving past the inductor **104**. In such an embodiment, the optical transmitter **900**-F is both powered by the moving magnet **102** and monitors the presence of the magnet **102** relative to the inductor **104**.

In one embodiment, the processor **404** includes a programmed delay. The programmed delay is initiated upon the processor **404** receiving sufficient power to operate. The programmed delay is sufficiently long for the processor **404** and sensor to become operational and for the processor **404** to respond to the multiple inputs **406**. In this way the output to the optical transducer **902** is initiated after the processor **404** has sufficient time to process the multiple inputs **406** and produce the specific signal corresponding to the inputs **406**. In various embodiments, the programmed delay is software executed by the processor **404** or a discrete delay circuit **106**.

In one embodiment, the processor **404** includes programming to output a signal to the optical transducer **902** where the output signal carries information related to the optical transmitter **900**-F and the various input signals **406**. In such an embodiment, the processor **404** outputs an identification code that uniquely identifies the optical transmitter **900**-F. The processor **404** also outputs with the identification code a data code identifying the input **406** and the value of the signal applied to that input **406**. The processor **404** outputs a data code for each of the multiple inputs **406**. The resulting data stream output from the processor **404** drives the optical transducer **902**. The receiver **910** is responsive to the signal from the optical transducer **902** and the receiver **910** decodes the data stream or communicates the data stream to another device, where the data is extracted and acted upon.

The single sensor burst transmitter system **10** includes various functions. The function of generating power and a trigger signal is implemented, in one embodiment, by the inductor **104**, which interacts with the magnet **102**.

The function of ensuring the transmitted pulse **306** is transmitted at a specific time is implemented, in one embodiment, by the delay **106**, which ensure the trigger input Tr is at a voltage sufficient to trigger the transmitter unit **108** before the transmitter unit **108** has sufficient power to be energized.

From the foregoing description, it will be recognized by those skilled in the art that a self-powered, single sensor burst wireless transmitter system **10** has been provided. The wireless transmitter system **10** has a minimal parts count, requires no external wiring, and has a low cost of installation and maintenance.

While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept.

What is claimed is:

1. An apparatus powered by a moving component, said apparatus comprising:

a power collector responsive to a magnetic field moving relative to said power collector, said power collector including an inductor;

a power converter connected to said power collector; and

an optical transducer powered by said power converter, said optical transducer sending an optical signal each time said power collector responds to said magnetic field with said power collector providing sufficient energy to said power converter to drive said optical transducer.

2. The apparatus of claim **1** further including a magnet that generates said magnetic field, and said magnet is dimensioned relative to the moving component such that said magnetic field is substantially a point source compared to a dwell interval.

3. The apparatus of claim **1** further including a magnet that generates said magnetic field, and said magnet is dimensioned relative to the moving component such that said magnetic field has a ratio of an interaction interval to a dwell interval of no more than 1:10, wherein said ratio is defined as a comparison between a first time that said magnetic field periodically interacts with said inductor and a second time that said magnetic field does not interact with said inductor.

4. The apparatus of claim **1** wherein a sole source of power for said optical transducer is said magnetic field interacting with said inductor.

5. The apparatus of claim **1** wherein said power converter includes a voltage multiplier configured to increase a voltage induced in said inductor.

6. The apparatus of claim **1** further including a processor powered by said power collector, said processor having at least one input, and said processor driving said optical transducer such that said optical signal is a data stream containing information on said at least one input.

7. An apparatus powered by a moving component, said apparatus comprising:

a transducer configured to transmit an optical signal;

a power converter providing power for said transducer;

a magnet having a magnetic field; and

an inductor responsive to said magnetic field when said magnet moves relative to said inductor, said inductor connected to said power converter, said inductor providing energy to said power converter when said magnetic field interacts with said inductor, said magnet dimensioned and configured such that an interaction interval of said magnetic field is substantially less than a dwell interval.

8. The apparatus of claim **7** wherein said magnet is configured to be attached to a component of a machine wherein said component moves relative to said inductor.

9. The apparatus of claim **7** wherein said power converter includes a Zener diode connected in parallel with said transducer, and said Zener diode sized to limit a voltage applied to said transducer.

10. The apparatus of claim **7** wherein power converter includes a transformer, said transformer being a step-up transformer producing an output voltage greater than an input voltage.

11. The apparatus of claim **10** wherein said power converter further includes a Zener diode connected in parallel with said transducer, and said Zener diode sized to limit a voltage applied to said transducer.

12. The apparatus of claim **7** wherein said power converter includes a current limiting resistor.

13. The apparatus of claim **7** further including a processor, said power converter provides power to said processor, said processor having at least one input, and said processor driving said transducer such that said optical signal is a data stream containing information on said at least one input.

14. The apparatus of claim **13** wherein said power converter includes a voltage multiplier connected between said inductor and said processor.

15. The apparatus of claim **14** wherein said power converter further includes a storage circuit connected to an output of said voltage multiplier.

16. An apparatus powered by a moving component, said apparatus comprising:

an inductor responsive to a magnetic field moving relative to said inductor;

a power converter connected to said inductor, said inductor providing energy to said power converter; and

an optical transducer powered by said power converter whereby said magnetic field causes said inductor to generate energy that said power converter provides power to enable said optical transducer to transmit an optical signal.

17. The apparatus of claim **16** further including a magnet that generates said magnetic field.

18. The apparatus of claim **16** wherein said power converter includes a voltage multiplier configured to increase a voltage induced in said inductor.

19. The apparatus of claim **16** wherein said power converter includes a Zener diode configured to limit a voltage applied to said optical transducer.

20. The apparatus of claim **16** further including a processor powered by said power collector, said processor having at least one input, and said processor driving said optical transducer such that said optical signal is a data stream containing information on said at least one input.

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